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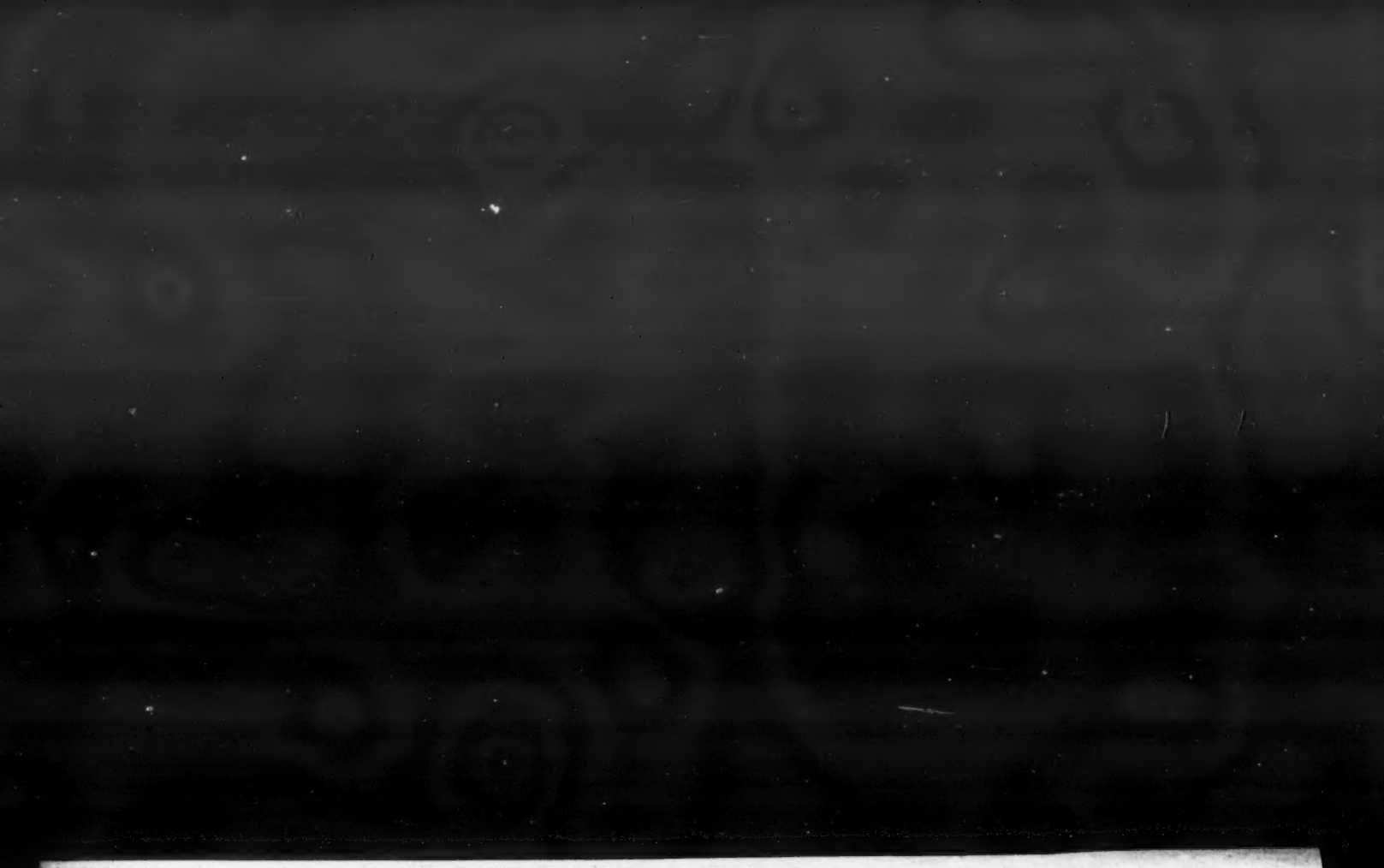


THE

AMERICAN JOURNAL OF SCIENCE

[THIRD SERIES.]

ART. VI.—*On the Relation of Gravity to Continental Elevation;* by T. C. MENDENHALL.

[Read at the November meeting of the N. A. S.]

NEARLY all of the earlier determinations of the force of gravity in the United States were made in the vicinity of the Atlantic Ocean, not more than one or two stations in the Mississippi Valley having been occupied previous to the year 1890. A determination had, however, been made on the Pacific Coast, at San Francisco, and pendulums had been swung for the same purpose on the summit of Mount Hamilton, at the Lick Observatory.

The development in the Coast and Geodetic Survey of the system of gravitation measure by means of half-second pendulums, to which reference has already been made in previous papers, made it possible, at a vastly less expenditure of time and labor, to execute an extensive series of gravity determinations as near as might be along the 39th parallel, extending from ocean to ocean, thus following nearly the line of the great trans-continental arc.

In the year 1893, an officer of the French Geographic corps, Colonel George Defforges, widely known for his investigations in connection with gravitation, visited this country, bringing with him pendulums which he had swung at several European stations, for the purpose of occupying the fundamental stations of the Coast and Geodetic Survey, and observing at a few isolated points which might be available during the period of his stay. Colonel Defforges swung his pendulums at several stations previously occupied by Coast Survey observers, and at

one or two stations in the interior at which the Coast Survey had not before observed. These fundamental stations, in connection with those already occupied by the American observers, made it possible to form a general idea of the variations of gravity along the trans-continental line and to compare such variations with elevations above the sea.

At a meeting of the National Academy in April, 1894, the writer presented a brief résumé of these results, including a diagram showing the departures of actual gravity from what might be called normal values.

During the summer of 1894 a very extended series of gravitation observations were made, by the new pendulum apparatus of the Coast and Geodetic Survey, by a party in charge of Assistant George R. Putnam. An examination of the details of the results of this series of observations proves that they were very carefully executed, and must be regarded as having a high value from the standpoint of accuracy. The results are of very great interest, and the special point to which attention is now called is the relation of this series of relative values of the force of gravity along this great continental arc to the various elevations above the sea of the stations at which the work was done. Below is a list of the stations occupied, arranged in the order of their longitude, beginning with Washington, near the Atlantic Coast, and ending with San Francisco, Cala.

Abstract of preliminary results of relative gravity observations with half-second pendulums.

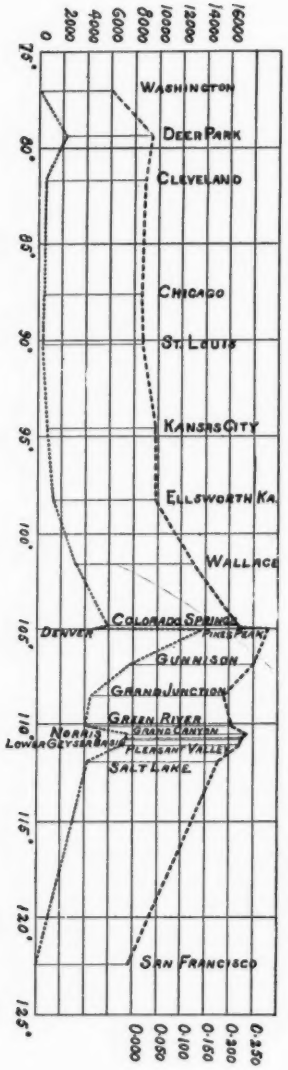
Station.	Lat.	Long.	Elevation in feet.	g observed.	g_0 at Sea Level.	g_0 Helmert.	$g_0 - g_0$
Washington	38° 53′	77° 00′	46	980·098	980·101	980·047	+·054
Deer Park	39 25	79 20	2515	979·921	980·068	980·094	—·026
Cleveland	41 30	81 40	689	980·227	980·268	980·280	—·012
Chicago	41 47	87 36	597	980·265	980·300	980·306	—·006
St. Louis	38 38	90 12	504	979·987	980·017	980·024	—·007
Kansas City	39 06	94 35	913	979·977	980·031	980·066	—·035
Ellsworth	38 44	98 14	1470	979·912	979·999	980·033	—·034
Wallace	38 55	101 35	3281	979·742	979·934	980·049	—·115
Colorado Spgs.	38 50	104 49	6063	979·475	979·831	980·042	—·211
Denver	39 41	104 57	5375	979·595	979·910	980·117	—·207
Pike's Peak	38 50	105 02	14140	978·940	979·769	980·042	—·273
Gunnison	38 32	106 55	7679	979·328	979·778	980·015	—·237
Grand Jct.	39 04	108 30	4570	979·620	979·887	980·063	—·176
Green River	39 00	110 05	4079	979·622	979·861	980·057	—·196
Grand Canyon	44 43	110 29	7828	979·885	980·344	980·571	—·227
Norris	44 44	110 43	7466	979·925	980·362	980·572	—·210
Lower Geyser Bas.,	44 33	110 48	7219	979·918	980·341	980·556	—·215
Pleasant Valley	39 51	111 02	7187	979·499	979·920	980·132	—·212
Salt Lake	40 46	111 54	4340	979·790	980·044	980·214	—·170
San Francisco	37 47	122 26	375	979·951	979·973	979·946	+·0265

It will be seen that there was no great variation in latitude among these stations, and that in longitude they are quite well

distributed, except that there remains for the time being a break of a little more than ten degrees between Salt Lake and San Francisco. It is to be hoped that the Coast Survey will in the near future be able to fill up this break. The elevations above sea level are also given, together with the force of gravity at each station. These values of the force of gravity must be accepted only tentatively, as it will appear that they are all made to depend upon the value at Washington. This value was adopted after an examination of several values for this point, some of which were not very satisfactory absolute measurements, and others the result of relative determinations at Washington and various absolute stations in Europe. It is not believed that the error of the assumed value is very great, and hence the table of values given may be considered as very close approximations to the absolute results. Relatively the degree of accuracy is, of course, very much higher.

Now the question of the existence at any point of an excess or deficiency of the force of gravitation is one which depends, of course, purely upon definition. Strictly speaking there can be no excess or deficiency of gravity at any point on the surface of the earth, for it must be whatever it is; but if comparisons be made of actual values with a theoretical distribution of the force of gravity some interesting conclusions can be drawn from an examination of the excesses and deficiencies. Accepting any spheroid, as Clark's spheroid of 1866, and assuming any distribution of gravity that may be chosen, the theoretical values may be calculated for any point on the surface of the earth, and the difference between these theoretical values and those actually observed would naturally lead to some conclusion as to the correctness of the theory of distribution which had been adopted. However, the greater part of the deviation of the observed values of the force of gravity at the several points given in the table above, from the values as distributed over Clark's spheroid, in accordance with the generally accepted formula, is due to the elevation of these points above the sea level. Now in order to bring such observations at elevated points into the same category as those observed at or near the surface of the imaginary spheroid, it is necessary to reduce them to the sea level, and in doing that we are obliged to take account not only of the actual diminution of the force of gravity due to the greater distance of the point from the center of the earth, but also the attraction of the continental mass which lies above the spheroidal surface. This correction is usually made by the application of a formula due to Bouger and used by him many years ago for making reductions of observations made by the Peruvian expedition of the French Academy. This formula is:—

$$\frac{dg}{g} = 2\frac{h}{r}\left[1 - \frac{3}{4}\frac{\delta}{\Delta}\right]$$



And it will be seen that it involves the relation between the density of the elevated mass and the mean density of the earth. It is usual to assume this relation as being equal to one-half; that is, to assume that the density of the surface material is one-half that of the mean density of the earth, and hence that it is about 2·75. On this hypothesis the excess of the force of gravity when reduced to the sea level over that as computed for the theoretical spheroid, by the use of Helmert's formula, is obtained, and the difference between these two quantities will be found in one of the columns of the table given above. It will be seen that nearly all of these differences are negative; that is to say, that the gravity as actually observed at the various points across the Atlantic is less than it should be in acccordance with the hypothesis above referred to. The accompanying diagram shows these variations in a very much simpler way than they can be exhibited in the table, and by plotting side by side the elevations of the several points and the difference in the observed and computed force of gravity referred to, the relation between the two is shown in a very striking manner. It will be observed that the two lines representing these quantities run side by side very closely, indi-

cating beyond a question a distinct relation between the deviations in the force of gravity and the continental elevation. It will be seen that even where small changes only take place in proceeding from point to point they are, almost without exception, in the same direction in both curves. The proper interpretation of this fact is perhaps not easy. In the formula of Bouger, which is made use of in this reduction to the sea level, the only quantity that can be at all in doubt, or at least seriously in doubt, is the term involving the relative density of the surface matter to that of the earth itself, the other terms referring only to the decrement of gravity due to elevation. It might at first seem, therefore, that an adjustment of this term could be made which would harmonize the theoretical value of gravity and the observed values; that is to say, it might appear that it would be only necessary to alter our hypothesis in regard to the density of the surface matter of the earth in order to remove the discrepancies that are shown in the table and are exhibited so vividly in the diagram. When this is attempted, however, it is seen that no reasonable hypothesis with regard to the density of the continental mass of the earth will account for these differences. Indeed, to account for them would require the assumption that the density of the surface matter was not only not one-half of the mean density of the earth, but that it was not even so much as one-third of the mean density, or possibly not one-fourth, and in some cases, indeed, that it must be nothing at all, so that it is difficult to make the hypothesis accord with the facts.

It may be well to remark that the studies of the trans-continental system of triangulation, which is now nearly completed along the 39th parallel, seem to show that the figure represented by Clark's spheroid is in very close agreement with the reality as developed by this scheme, so that no large discrepancies in the value of the force of gravity can be expected to result from any possible error in the representation of the geoid by this figure.

These results are certainly of much interest and importance to geologists, and it seems that they may, when the subject is sufficiently thoroughly investigated by further determinations widely and properly distributed, throw considerable light on the internal structure, and the formation of that part of the earth lying nearest the surface. They evidently demonstrate the great value and scientific interest of gravity determinations, conducted as skillfully and as rapidly as have been these under the direction of Mr. Putnam.

In connection with this subject, it may be of interest to add that during this campaign a number of comparisons were made of the half-second pendulum system, which was generally used

throughout the work, and the system of quarter-second pendulums for gravity purposes exhibited and described at a previous meeting of the Academy. These little pendulums, not more than five or six centimeters in length, have proved, under the test to which they were thus submitted, to be quite accurate and reliable in their performance, and their lightness and convenience in transportation will doubtless render them of considerable service in future gravity campaigns where the conditions of travel and observation are difficult and trying. It was also observed, by very careful comparisons of the periods of the pendulums of both types, both before and after the campaign made at the base station at Washington, that there was almost. if not quite, no sensible wearing of the agate knife edges, thus demonstrating the efficiency of the combination of plane and edge which was a year or two ago first presented to the National Academy.*

ART. VII.—*Observation upon the Glacial Phenomena of Newfoundland, Labrador and Southern Greenland;* by G. FREDERICK WRIGHT.

Dr. F. A. Cook's expedition to the Arctic regions in the summer of 1894 met with many reverses, ending in the loss of the Steamer Miranda and of the valuable collections which had been made by the naturalists on board. But the opportunities for glacial investigation were on the whole as good as could have been reasonably expected. The delays afforded nearly a week for observations in Newfoundland, and about the same length of time at three different points in Labrador, namely at Henley Harbor, St. Charles Harbor, and the Punch Bowl, while two weeks were at our disposal in Greenland in the vicinity of Sukkertoppen in latitude 65·25, where the inland ice sends a projection down to within fifteen miles of the open sea. Besides spending a week in camp at the edge of this portion of the inland ice, we made an excursion up Isortoki Fiord to a distance of twenty-five miles, having oppor-

* Since the above was written I have received a letter from Mr. Putnam in which he informs me that he has since added two or three stations to the list as given above. He also makes the important suggestion that a similar line of gravity stations should be run across the southern part of the country. "We would then," he says. "get in another latitude a variety of conditions not found in the past season; a sea coast free from the mountains, along the Gulf Coasts an immense area of deposits, farther to the west a long, rising swell comparatively little disturbed with mountains, and beyond a great depression below sea level." It is earnestly hoped that he may be allowed to execute this interesting piece of work.

tunity to study the phenomena along each side to that point, and to get extensive views of the inland ice and of the country bordering it.

The glacial phenomena of Newfoundland have been very carefully studied by Mr. Alexander Murray and fully recorded in his paper before the Royal Society of Canada in 1882, published in the Proceedings and Transactions of that year, Sec. iv, pp. 55–76. I have little to add to what he has written, except to set the facts in their connection with those observed in Labrador and Southern Greenland, so as to assist in forming certain general conclusions.

The west coast of Newfoundland presents a nearly straight face to the sea, running about N.N.E. and S.S.W. The southwestern portion of the western coast rises in Cape Anguille to a height of 1800 feet. The rounded or sloping escarpments usually face to the westward, as if the ice-movement from that direction had covered the whole island.

The southeast and east coast is deeply indented with numerous large bays which for the most part trend in lines nearly parallel with the western face of the island. Grand Pond, whose surface is 116 feet above tide, has a depth of more than 1000 feet, its bottom being 988 feet below sea-level. The evidences of former occupation by glacial ice are universal in the island; glacial striae being found not only in the valleys opening out into the Atlantic, but upon the highest headlands. In the vicinity of St. John's the direction of the scratches varies, according to Murray, from N. 64 E. to S. 76 E. upon the higher lands, which are from 300 to 600 feet above the sea. On the summit of Signal Hill, which is about as high a point as there is upon the peninsula of Avilon, the direction of the scratches is S. 86 E. At Torbay, a few miles north, at 300 feet above tide, the scratches are S. 76 E. On the Great Belle Island in Conception Bay the direction is N. 38 E., or very nearly in line with the axis of the bay. At Topsail Head, however, which lies on the south side of the bay, just opposite the island, and 650 feet above tide, the scratches point, according to Murray, N. 43 W. It seems to me, however, a fair question, whether the direction of movement was not here S. 43 E., bringing it nearly in line with the scratches upon the rocks on the highlands between Topsail Head and St. John's.

So far as I could learn, the transported material in the vicinity of St. John's is local, the bowlders on Signal Hill being all traceable to outcrops a few miles west, where the land is very nearly upon a level with the summit of the headlands. Taken altogether, and in connection with the phenomena in Nova Scotia and Labrador, and with the soundings

of the surrounding sea, there seems every reason to accept the conclusion of Mr. Murray, that the glacial phenomena of Newfoundland belong to a general movement which filled the Gulf of St. Lawrence and extended some distance out upon the Atlantic plateau in this latitude. 1st. The glacial scratches which appear near the summits of the highlands are often at right angles to those appearing in the shallow valleys, indicating a movement, at the climax of the period, which was largely independent of local features. At St. John's there is a considerable accumulation of till upon the southeast side of the harbor up to about 200 feet; but there are very few indications of any vigorous movement of ice along the axis of the harbor. It was with difficulty that I found any indications of movement at all underneath this till. The whole appearance was that the harbor had been filled with nearly stagnant ice, having but a slight movement making very fine scratches in the direction of the axis of the upper part of the harbor, which was northeast, or about at right angles to the scratches upon Signal Hill, and to those near the summit of the hill upon the south side of the harbor.

2. The depth of Grand Pond (988 feet below sea-level) coincides with numerous other facts indicating a preglacial elevation. In Conception Bay the general depth of the water is from 100 to 140 fathoms; but the depth across the mouth is only 80 fathoms, indicating a bank which is most likely a terminal moraine. The mouth of Holyrood Bay is crossed by a similar bank, convex on the inside, and is covered by only thirteen fathoms of water, while it suddenly deepens on both sides to forty fathoms. As is well known, also (see especially a paper by Prof. J. W. Spencer, Geol. Soc. of Am., vol. i, p. 68), the shallow water surrounding Newfoundland, and extending to Nova Scotia, is intersected by a deep channel extending from the Saguenay River down the St. Lawrence and through the Gulf, south of Anticosti Island, to the margin of the plateau which suddenly breaks off into the profounder depths of the Atlantic Ocean, about 200 miles from the present land margin. This channel is, throughout its entire length, more than 1200 feet in depth, reaching towards its mouth a depth of nearly 2000 feet. Throughout its entire length, also, it is pretty sharply bordered by a margin of shallow water less than 500 feet in depth.

3. Along the coast of Labrador the most instructive feature of the scenery is its subdued character, especially when contrasted with the west coast of Southern Greenland. From the Straits of Belle Isle to Hamilton Inlet the entire coast came within reach of our vision. Everywhere the land rises pretty rapidly to heights of from 1000 to 2000 feet. But though the rocks

are of Laurentian age, consisting of granite and gneiss, which would naturally weather into sharp peaks, the summits present everywhere a flowing outline. So far as we observed, there was not a single needle-shaped peak to interrupt the monotony of the scene. At St. Charles Harbor and at the Punch Bowl we spent several days in wandering over the hills near the shore, some of them rising to an elevation of nearly 1000 feet. But it was with the greatest difficulty that any glacial scratches were found upon the rocks, while the absence of till and of transported bowlders was equally remarkable. Similar absence of these characteristic glacial signs was noted by Prof. Carl Kenaston, who accompanied Mr. Bryant to the great falls on Grand River, nearly 200 miles inland. Still there can be no question that this whole region was enveloped in glacial ice. The absence of till probably accounts largely for the absence of scratches; for in that inclement climate disintegration of granitic rocks proceeds at a very rapid rate; so that we have few freshly exposed surfaces that have not suffered considerable disintegration. At Henley Harbor, which opens southward upon the Straits of Belle Isle, large granite bowlders were found upon the Devil's Dining Table, a remnant of an extensive basaltic eruption, which rises 250 feet above the sea-level. But around St. Charles Harbor and the Punch Bowl, it was very difficult to find any bowlders at all. The natural explanation would seem to be that we are here so near the center of a great glacial movement that all the sharp peaks were worn down, and the material carried away to points nearer the margin of the movement. It seems altogether likely that an ice-front stretched along near the border of the continental plateau as far as the banks of Newfoundland. But glacial conditions were, most likely, a concomitant of the elevation, so that the confluent glaciers spread out there upon the continent as they did in the interior portions of America.

Passing to Southern Greenland, one is deeply impressed by the great contrast in the scenery, though the geological formations are essentially the same. We had a view of the Greenland coast from the vicinity of Frederickshaab to the vicinity of Holstenborg, a distance of about 300 miles. While from Sukkertoppen, in lat. 65° 25′, we were able to make extensive tours into the interior up the fiords and along the channels and to make a minute study of a considerable section. The rocks are principally gneiss, with occasional veins of granite and trap. But instead of the flowing contour characteristic of the mountainous border of Labrador, the scenery of this part of Greenland as viewed from the ocean is extremely picturesque—needle-like peaks of Laurentian rocks running up at frequent intervals to heights of from 2000 to 4000 feet.

Nothing in the Alps or the Rocky Mountains is more characteristic of the forms assumed by such rocks under subaerial erosion than the numerous sharp peaks to be found all along this part of Southern Greenland. One has not far to go in the interior, however, to find the same subdued topography already noticed in Labrador. Upon penetrating Isortok Fiord 25 miles, the peak of Nukagpiak rises 4180 feet. From its flanks a projection of the inland ice-sheet can be seen 15 or 20 miles to the north. This ice-field is penetrated by two or three nunataks of about the same height with this mountain. But the elevated region intervening between this point and the eastern ice is characterized not by sharp peaks, but by truncated masses that have been rounded and smoothed by glacial, rather than by subaerial erosion.

On the contrary, the island of Sukkertoppen, which is about five miles in diameter, and still farther north the island of Sermerut, which is about ten miles in diameter and rises to an elevation of 3300 feet, present on every side a continuous line of conical peaks which show every characteristic mark of having been sculptured mainly by water and subaerial agencies. As seen from the channels to the southeast, their outline, when thrown against the glowing sky of the north at midnight, is the most picturesque I have ever witnessed,—to be compared with that of the Teton Mountains when seen from the east or the west, and with the Aiguilles around the upper part of the Mer de Glace; while the view is scarcely less impressive when seen from some of the adjoining heights. They present none of the characteristics of a region which has been completely covered with glacial ice. If they have ever been so covered, an enormous time must have elapsed since the recession of the ice-sheet on that part of the coast.

But while it is not probable that the ice ever covered these marginal peaks, it is clear that at one time glaciers extended through all the fiords and filled all the channels to the very border of the sea. This is indicated both by glacial striæ and by transported bowlders. In Isortok Fiord, which is now open back into the interior for 50 or 60 miles, and is bordered all the way by mountains 2000 or 3000 feet high containing local glaciers, glacial groovings are magnificently displayed near its mouth, where I had opportunity to observe them upon a scale scarcely inferior to that witnessed on Kelley Island, in the western end of Lake Erie, or in the vicinity of Victoria on the Island of Vancouver. (See illustrations in the Ice Age of North America, pp. 156, 237–245.) So powerful was the movement of ice at this point that it did not confine itself to the direct axis of the fiord, but pushed obliquely upwards toward a low promontory several hundred feet above sea-level,

while the flank of this promontory facing to the southeast was marked by two or three clearly defined moraines composed mostly of pretty well rounded bowlders. Below the 200-foot level these had evidently been partially rearranged by wave action. But there was here a large amount, also, of till running down to the water's edge which had not been thus modified. This deposit of till was larger than any other which I saw in Greenland.

In the fiord at Ikamiut, about 20 miles north of Sukkertoppen, and directly east of the Island of Sermersut, the glacial phenomena were of the most significant kind. This fiord extends back from the open channel about eight miles, where it is met by the perpendicular ice-front of an extensive glacier which here projects from the inland ice. The height of this ice-front is from 100 to 200 feet, and the width of the fiord two and a half miles, but for about a third of its distance the ice terminates on gravel deposits that had been laid down in front of it. On the northern side of the glacier the ice is much broken, rendering it impossible for one to traverse it. The motion of the ice, however, is evidently very slow; for, though the front is perpendicular, the icebergs that break off from it are small and few, even when compared with those from the Muir Glacier in Alaska, and the water from the subglacial streams is only slightly colored by the glacial sediment.

We ascended this glacier along its southern edge for a distance of six miles, reaching an altitude of 1800 feet, where a very sharp and high *nunatak* divided the glacier which was here from six to eight miles wide.

Upon looking back over the space we had traversed we could see that at the head of Ikamiut fiord the glacier encountered a mountain rising 4000 feet which caused it to divide and put off two branches, one to the northwest and one to the southwest. The southern fiord leads directly down to Sukkertoppen, and is twice as long as that leading to Ikamiut.

From our point of view we could easily see that the southern fiord was much more encumbered by floating ice than the northern. From this point, also, the rugged and angular contour of the mountains along the coast were strikingly noticeable. Upon looking to the east the ice-cap, covered with freshly fallen snow, stretched away beyond the nunatak as far as the eye could see. We were looking out upon the same icefield which we beheld two weeks before from Nukagpiak, at a right angle on the south side of Isortok fiord and twenty miles distant.

Among the most impressive phenomena upon this glacier were the majestic swells in the ice as it broke against the mountain barrier between the two fiords. In vast masses sepa-

rated by long fissures the ice turns to the right and to the left towards the head of the fiords, while opposite the mountain barrier it is pushed up in a smooth dome-shaped protuberance, so that when we were in the depression between the descent from the ice-field to the ascent towards the mountain, the appearance was almost exactly like that which often confronts one in a "sag" in a rolling prairie.

Above the height of 1500 feet the glacier was so covered with fresh snow that there was little opportunity for observation. Below this level there were numerous superglacial streams of large size, which eventually plunged into moulins several hundred feet deep. The surface of the ice from which the fresh snow had melted contained a large amount of fine dust corresponding, I suppose to Nordenskiöld's *kryokonite*. In shallow depressions this was occasionally an inch or two in depth. We estimated that, over considerable areas, the average thickness of the dust was a quarter of an inch. The height and bareness of the surrounding mountains favored such an accumulation, as the winds had free access to them. Unfortunately our specimens were lost, so that I have not been able to compare the dust found here with that described by Nordenskiöld and Holst; but the general appearance was similar to their specimens.

Numerous moraines, coming principally from the northern side of the glacier, joined to form two main lines before reaching the head of Ikamiut fiord. These stood considerably above the general level of the ice. One of the moraines was spread out over a width of fully a quarter of a mile,—that appearing to be the distance to which the stones had rolled transversely in the process of the lowering of the level of the ice in recent times by ablation. The number of perfectly rounded pebbles six inches or more in diameter interspersed a mile or more back from the front with this morainic debris upon the surface of the ice was such as to attract special attention.

Ikamiut fiord presents one of the best object lessons conceivable illustrating the process which went on everywhere in mountainous regions during the closing stages of the ice invasion. The fiord runs nearly east and west. The flanks of the mountain upon the north side of the fiord facing the sun, are entirely free from ice up to the border of the glacial front; but those upon the south side facing the north sustain a number of local glaciers fed by comparatively small neve-fields and extending varying distances towards the water's edge. The glacier nearest the mouth of the fiord comes down to within about 1000 feet of the sea-level, a second, farther up the fiord, reaches down to within about 500 feet of sea-level, a

third descends still nearer, while a fourth comes to the water's edge close to the ice-front of the main glacier. Still farther eastward, and higher up the mountain, a glacier is moving directly against the general ice movement. The face of the rocks upon the south side of the fiord are very plainly striated in the direction of the axis of the fiord up to a height of 1000 feet or more; while the present local glaciers are now producing scratches in numerous places at right angles to those produced when the fiord was full of ice, and a little above the head of the fiord the scratches produced are directly opposite to those which were made at the time of the maximum extension.

There is very little till to be found anywhere along this part of the Greenland coast, and when one considers the indications of the former extension of the ice down the fiords he is surprised at the small number of bowlders upon the surface. It is probable, however, that the bowlders have been largely dumped into the fiords. The moraine upon the main glacier, though very large, could easily disappear in the great depths of Ikamiut fiord after the ice had melted away. In the vicinity of Sukkertoppen there were a few bowlders of light colored granite so different from the gneiss of the vicinity as to furnish indubitable evidence of transportation by ice from a considerable distance in the interior.

I could find no indications of high terraces along this part of the Greenland coast. In a few protected places, however (at Sukkertoppen and Ikamiut and at the locality already referred to on the Isortok fiord), there was an arrangement of large numbers of rather small subangular bowlders which indicated a limited amount of water action up to a height of 200 or 300 feet. At Ikamiut shells were found in abundance in a terrace about 50 feet above tide-level. I saw no evidences of "englacial" till. The perpendicular face of the glacier seemed to be pure ice.

The most important inferences to be drawn from the foregoing facts are:

1st. That the ice-sheet of Southern Greenland formerly sent glaciers down through all the fiords, filling them to a height of about 2000 feet, and pushing even to the very margin of the continent. Greenland, therefore, like the rest of the world has had its ice age which has already partially passed away.

2d. During the maximum of the ice extension the mountains bordering the sea in Southern Greenland formed innumerable nunataks. The ice was not thick enough to cover them in solid mass, and there is no probability that the ice extended far out into Davis Straits.

3d. On the other hand, it is pretty evident that in Labrador and Newfoundland all the mountains were completely covered with glacial ice, which extended far out over the bordering continental plateau. But this was at that time probably elevated above the sea-level, so that it is doubtful if the ice ever extended far into the sea. The facts point to considerable preglacial elevations of land followed in Labrador, at least, by a period of extensive depression below the present level, and subsequent partial elevation.

4th. The freshness of the glacial striæ in exposed places and the small amount of modification which has taken place in the topography since the retreat of the ice sustains the abundant evidence elsewhere found of the recent date of the glacial period; while the indications of recent changes of level point to terrestrial rather than astronomical causes to account for the vicissitudes of the glacial period.

ART. VIII.—*On the Recurrence of Devonian Fossils in strata of Carboniferous Age;* by HENRY S. WILLIAMS.

[Read before the Geological Society of America at Baltimore, December, 1894.]

THE fossils which form the subject of the following remarks were brought to my notice by Dr. J. C. Branner during the progress of the Geological Survey of Arkansas. They were collected by various members of the survey from a dark colored limestone and associated calcareous shales at Spring Creek, a few miles west of Batesville. The first batch of fossils sent me were in a rotten-stone, originally a sandy limestone, and seemed to be identical with the *Leiorhynchus quadricostatum* of the Devonian rocks of New York, which led to my reporting them to be of Devonian age. Afterwards fossils from the same ledge were sent which were reported in my correspondence to be of undoubted Carboniferous age. As the presence of Devonian rocks was looked for but had not been definitely proven the find was of considerable interest, but the confusion in my identifications led naturally to suspicion of either mixing of the evidence or error in the identifications.

McChesney* had previously described a few fossils as coming from dark shales near Batesville, Ark., and probably of Hamilton (Devonian) age (*Nucula Vaseyana*, *Nucula? rectangula* and *Pleurotomaria nodomarginata*). And the black shales met with in the same part of the State and farther west, have

* Descriptions of fossils, Chicago Acad. Sci., vol. i, pp. 37, 40 and 47.

been supposed to be equivalent to the "black shales" of Tennessee and of Devonian age.

More fossils were collected and the Arkansas geologists examined the locality with special care but with the result of confirming the singleness of the horizon from which the fossils came and the certainty of the duplicity of the testimony of the fossils themselves. Finally, Drs. Branner, Penrose and I went together and examined the locality with special care and sent in a collector, Mr. Weller, to make full collections of the fossils of the neighborhood, and the materials are now being elaborated for a full report of the fauna. On account of the importance of the facts this preliminary announcement is made.

The geological age of the Spring Creek limestone is established to be younger than the Batesville sandstone and older than the Boone chert, of the Arkansas survey nomenclature, which makes it equivalent to the Warsaw or St. Louis limestone of Missouri and the Mississippi Valley sections in general. Three kinds of evidence confirm this determination: The stratigraphy of the immediate neighborhood of Spring Creek, and second the correlation of the fauna with faunas of the same general region of higher and lower horizons, and third the comparison of the species of the fauna with those of a different geological province whose age is established on independent evidence. The stratigraphical evidence is as follows:

The locality is in the northern part of Arkansas, geologically on the southern slope of the Ozark uplift, which centers in southeastern Missouri, where the upper paleozoic terranes lie with a general dip southward and southwestward, with thin upper edges graded toward the north so that outcrops are of older and older rocks on passing northeastward from Spring Creek, a point a mile or so west of Batesville. There is a fault near the point where the fossils come from running northeasterly, the southeasterly mass has fallen below the northwesterly mass. The Spring Creek limestone is on the northwest side of the fault hence the occurrence of the Devonian types cannot be explained as having been caught in a fault, since the other side of the faulted rock has been dragged down, leaving more recent and not older rocks at the same horizon on the opposite side.

The strata underlying the Spring Creek limestone was shown to be the Boone chert (= Keokuk-Burlington of Missouri, Illinois, Iowa, etc.). The Batesville sandstone above it contains a fauna closely like the fauna of the St. Louis limestones in some of its species. At Mountain view some of the same species are reported from a similar stratigraphical position. In its more western exposures, according to the interpretation of the Arkansas geologists, the same interval is occupied by the Fayett-

ville shales. There is common agreement on the part of all the geologists of the survey who have studied the region that the stratigraphical position of the Spring Creek limestone is between the Batesville sandstone (= Chester-St. Louis horizon) and the Boone chert (= Keokuk-Burlington horizon).

The second method of determination is by identification of the fauna with other faunas of known age. The general Carboniferous age is clearly indicated by the presence of *Productus* of the types of *cora* and *semireticulatus*, of Spirifers of the *S. bisulcatus* type of the Carboniferous limestone of England and elsewhere, and further by the identity of several of the species with those in the neighboring formation containing only faunas of the upper formations of the Mississippian series ("Subcarboniferous"). The species are not in general strictly identical with species of any of the typical divisions of the Mississippi Valley Carboniferous, and it is necessary to use the third method of correlation to reach greater precision than a general correlation with faunas of neo-Carboniferous age.

According to the third method we compare the species with faunas of other regions whose age is determined, and this reveals some of the more interesting features of the case. Upon making close identification of the fauna it is found that one of the most characteristic and abundant species in the fauna of the Spring Creek limestone is identical with Walcott's *Rhynchonella Eurekensis** of Lower Carboniferous limestone of Secret cañon road Cañon and the Cañon of Pinto Park of Eureka District, Nevada. This is a unique species, no Rhynchonella like it is reported from North America, but it is represented by several European species from Devonian horizons, or more ancient (cf. *R. Dumonti* Gosselet, Devonian of Ardennes; *R. princeps* var. Barrande; *R. livonica* v. Buch, Wenukoff, Tab. V, fig. 3. Russian Devonian). It resembles also the striated varieties of the recent *Rhy. psittacea*. *Pleurotomaria nodomarginata* McChesney, referred to above, or a very closely allied form is among the Spring Creek species. Walcott identified the same species in the Secret Cañon road Cañon locality in Nevada.

When the fauna is compared with the fauna of Eureka district three-fifths of the genera are the same, and many of the species closely allied. The same close generic resemblance is seen on comparing the former with the Baird shale described by J. P. Smith† from the U. S. Fisheries in Shasta County, California, and both these western faunas are peculiar in holding species which are of markedly Devonian type, though the

* Monograph, Paleontology of the Eureka District, p. 223.
† Journal of Geology, vol. ii, Sept.-Oct., 1894, p. 594.

majority of the species are so typically Carboniferous as to leave no doubt of their Carboniferous age.

In describing the Lower Carboniferous fauna of the Eureka district Mr. Walcott says:

> There is also a certain commingling of upper Devonian species with the lower Carboniferous fauna. We find *Discina Newberryi*, *Macrodon Hamiltonia*, *Grammysia Hannibalensis*, *G. arcuata*, *Sanguinolites Aeolus*, *Pleurotomaria nodomarginata* associated with common Carboniferous species.—*Pal. Eureka District*, p. 8.

The same commingling of species is noted by J. P. Smith.* He states that 29 of the 84 species of the Baird shales of Shasta County, California, are identical with the

> forms described by Walcott from the lower Carboniferous of the Eureka district, and in this Baird shale fauna are such Carboniferous species as *Productus Burlingtonensis*, *P. giganteus*, *P. Nebrascensis*, *P. punctatus* and *P. semireticulatus*, *Spirifer lineatus* and *S. striatus*. But in the California fauna 15 species are found which are known Devonian fossils of Eastern America.

In my manuscript report on the Arkansas fauna to Dr. Branner, I had suggested the relationship between the Spring Creek and Eureka faunas, and Mr. Smith who had read it before writing his paper on the Shasta faunas noticed the confirmation his species furnished of this interpretation. The Shasta and Eureka faunas find an unmistakable representative in the fauna of the Spring Creek limestones of Arkansas, and the fact that they differ from the ordinary Carboniferous faunas of the Mississippi Valley in the particulars which associate them with these faunas west of the Rocky Mountains is a strong argument for the theory that this Spring Creek fauna migrated into the seas over Arkansas from the west, was there only temporarily and was soon withdrawn or destroyed, leaving only this solitary record of its existence in the series of the Mississippi Valley. Thus all the evidence in hand points to the Carboniferous age of the Spring Creek limestone, and there are sufficient reasons for referring it to the lower third of the Carboniferous (the Mississippian); and its correlation with an horizon about equivalent to the Warsaw, St. Louis, or the Spergen Hill formations is strongly suggested.

As a general fauna, this Arkansas fauna is more closely allied to those of Eureka District, Nevada and of Shasta County, California, than to any other fauna in the Mississippi Valley or farther east. Both of these western faunas, although presenting species of Devonian type commingled with the Carboniferous species are separated by considerable thickness of strata from

* Journal Geol., vol. ii, p. 597.

the latest Devonian horizon of the local section; by three thousand feet of conglomerate in the Eureka District, and by some, at present, unknown amount of sediments in Shasta County, California.

The second point requiring verification is the presence of actual Devonian species in this limestone of Carboniferous age. There are two species both of which are represented by numerous specimens in the same strata with the Carboniferous species: they are *Leiorhynchus quadricostatum* Vanuxem, and *Productella lachrymosa*, varieties *stigmata*, *onusta*, etc. Hall.

The first of these species was reported by Meek from the White Pine Mountains, Eureka District (=White Pine shale of Walcott) in 1877.*

The age of these shales, was, in the same report (p. 201), referred to the Devonian by Hall and Whitfield on the evidence of this species and a *Lunulicardium* (*L. fragosa*, Meek sp.) and an *Avicula* (*A. equilatera*), while the beds immediately above were called Carboniferous without hesitation. Walcott noted the mixture of the Devonian and Carboniferous† species in this White Pine shale, but concluded from study of the section that the beds in question covered a fauna uniting the two systems but of pre-Carboniferous age (p. 6).

The second species in some of its varieties is also reported by Walcott from Upper Devonian limestones of the Eureka District‡ associated with many typical eastern Devonian species. The *Rhynchonella Eurekensis* Walcott, found in the Lower Carboniferous limestones of the Eureka District above, and separated from the White Pine shales by 3000 feet of quartzite conglomerate, is associated with the two above-mentioned Devonian species in the Spring Creek limestone of Arkansas. The two species *L. quadricostatum* and *P. lachrymosa*, have been regarded by Meek, by Hall, Whitfield and Walcott as Devonian species. They are characteristic of Devonian rocks of New York, although the *Leiorhynchus* has been reported, with early Carboniferous species in Pennsylvania, as it has in Nevada. Not only the species but the subgeneric types in both cases are Devonian; both *Productella* and *Leiorhynchus* are characteristic Devonian modifications of the genera *Productus* and *Rhynchonella* respectively. These two species then are not only characteristic Devonian species but Devonian subgenera, and where seen in Nevada they are still below the fauna with which the general fauna of the Spring Creek limestone is correlated in the Nevada sections.

* Geol. Expl. Fortieth Par., vol. iv, p. 79.
† Paleontology of the Eureka District, p. 5.
‡ l. c., p. 132.

The contrast between the Nevada and the Arkansas sequence is seen in the fact that in the Arkansas section, the faunas above and below the Spring Creek limestone are typically Carboniferous and do not present admixture of Devonian forms, while the Nevada and, from present reports also, the California sections from Devonian far into Carboniferous time present remarkable commingling of Devonian with Carboniferous types. The 3000 feet of conglomerate in Nevada, reported by Walcott as separating the White Pine shale from the Carboniferous limestone with *Rhynchonella Eurekensis*, suggests the cause of the appearance of this western fauna in the Arkansas region, i. e. an elevation of the western area sufficient to cause diversion of the ocean currents and shifting of such species as endured the transport into the Mississippi Valley area. In the Appalachian province the Devonian species are still more sharply distinct from the Carboniferous forms than in the Mississippi Valley.

These are the facts in the case: in northwestern Arkansas is found a fauna in the Spring Creek limestone which by its stratigraphical position and general fossil contents is shown to be of Carboniferous age, separated by at least two well defined and distinct faunas (the Kinderhook-Chouteau and the Burlington-Keokuk) from the latest Devonian fauna of the Mississippi basin province, but containing several species which in the more eastern Paleozoic sections are, both specifically and subgenerically, Devonian forms.

One of the species is known only from a Carboniferous horizon of the western part of the continent, and others are distinctive of more western faunas in which the commingling of Devonian and Carboniferous species is conspicuous.

The recurrence of the Devonian species in the Arkansas Carboniferous rocks is most readily explained as a case of migration of species from a region in which they had continued to live unchanged, into a region from which they had for a long time been absent or into which they had never before entered. It is an example of the living on of species in one locality long after they had become extinct or were replaced by other species in another region. This is not an anomalous fact; the Australian land fauna is a remarkable illustration of the same law. Deep sea dredgings have shown the same fact in regard to some of the abyssal species which are of Eocene or Cretaceous type, ancient characters having been preserved in the ocean depths while they have been superseded by evolved successors in other environments. But the interesting point in this Arkansas case is that we have here a suggestion as to the cause of the unchanged continuance of the species. The recurrent Devonian species were evidently asso-

ciated with a generalized as contrasted with a specialized fauna.

The faunas of the Devonian and Carboniferous in Nevada and California are peculiar for showing a very long continuance of the same general fauna, with changes by the accession of new species as time progressed, but with remarkable persistence of early species unchanged. Walcott called attention to the fact in his Nevada faunas. The great thickness of Devonian rocks shows not only long range of species but such mingling as to bring species supposed to be characteristic of Upper Devonian in the east down at the base of the series in Nevada. In the Appalachian series we find the opposite to be the fact, the faunas are much broken up into distinct zones, with very few species tying together the successive faunas. And this breaking up of the faunas is plainly associated with oscillating levels and general passage from pure marine conditions up to brackish water, and finally by the closing of sedimentation upon elevation of the bottom above the sea-level. This is shown by the passage from limestones of the Lower Devonian into shale, sandstone and conglomerate—in the succession of deposits that followed.

Taking the first full appearance of a characteristic fauna as indicative of common horizon for each of the separate provinces, we observe that in the Appalachian province the Devonian species are more closely restricted to the Devonian age. In the Mississippi province, after the Devonian stage is sharply closed, this case of recurrence is seen well up in Carboniferous faunal succession, while in the western continental border there was a mixture of Devonian and Carboniferous species all along the way till the characteristic Carboniferous species were present in full force in the prevalent fauna. This later and later removal of the earlier types from the prevalent faunas as we pass westward across the continent is coördinate with the continental expansion occurring at the same time. The conclusion seems evident that the cutting off of the Devonian species was in some way associated with the progress of the continental border westward during later Devonian and the first half of Carboniferous time. The coal measure conditions, were as early as the Warsaw and St. Louis limestones in Pennsylvania, if not still earlier, and limestone had ceased to be a factor in the deposits in northern Pennsylvania and New York, before the Chemung began. In the Mississippi Valley limestones continue up to the Chester, and then the sands, conglomerate and coal measure condition suddenly appear.

Before we reach the central ridges of the Rocky Mountains the limestone conditions are prevalent till the upper coal measure time, and still further west there are no indications of any

continental lands sufficient to disturb the reign of the marine faunas till near the close of the Carboniferous age. Thus in the Appalachian province diversity and alternation of deposits is marked by numerous successive and distinct faunas; in the western continental border province uniformity of prevailing calcareous sedimentation for long periods is marked by the abnormally long continuance of many of the Devonian species; while the central continental province midway between the two is marked by the unmistakable recurrence of Devonian species far up in the midst of Carboniferous sediments.

While theoretically such a fact might be expected, this unique case of recurrence furnishes us with the evidence connecting the three distinct geological provinces, and makes it possible to correlate, with more than ordinary precision, the chronological horizon of the several widely separated faunas. This series of observations furnishes a demonstration of the hypotheses that the persistence of species without modification is associated with continuance of uniformity of conditions of environment, and that change in the successive faunas of geological time is associated with the change and rearrangment of the conditions of environment to which the fauna is subjected.

Art. IX.—*Constituents of the Cañon Diablo Meteorite;* by Orville A. Derby.

A specimen of the Cañon Diablo meteorite obtained from Mr. E. E. Howell of Washington and stated to be one of the original lot brought from Arizona by Dr. A. E. Foote, has been treated in the laboratory of the Commissão Geographica e Geologica de São Paulo by the fractional method of Prof. E. Cohen with the following results. The chemical analyses accompanying this paper have been kindly made for me by Dr. Guilherme Florence, assistant to the Commission.

The specimen, weighing nearly 200 grams, was a perfect meteoric individual; that is to say, it presented no fractural surfaces, but everywhere the rough pitted surface of meteoric masses. In appearance it suggested a metallic bleb broken or weathered out of friable, or more easily decomposable, material. An examination of a considerable number of specimens of all sizes in Mr. Howell's collection shows this to be a general characteristic of the Cañon Diablo group. Nothing in the shape and aspect of the masses suggests the occurrence of planes of slight cohesion (presumed to be the limits of crystalline

individuals, such as in a paper now in press, I have described under the name of Wollaston Planes, in the Bendegó mass) and which, by facilitating fracture either in the original place of formation, or in the act of falling, have probably produced the approximately plane faces and angular edges that characterize that meteorite. Such faces and edges might be expected on the Cañon Diablo masses on the hypothesis of their being fragments of a single homogeneous mass, which seems to be required by the conditions under which they were found. A rough, jagged and pitted surface is however common to all of them, showing a perfect individualization and suggesting on a large scale, the small, irregular metallic masses scattered through the stony matrix of a mesosiderite. Referring them to a single original mass, the hypothesis may be ventured that, on its arrival in our atmosphere, this was not homogeneous but consisted of a large mesosiderite with unusually large metallic nodules that became separated by the explosions attending the fall, and probably also by subsequent decay and disaggregation of the stony matrix.*

After freeing the specimen as far as practicable from its rust crusts by scraping after a soaking in strong acid, it was treated with cold hydrochloric acid of a strength of 1 to 10. The solution was effected slowly with evolution of gas and a separation of a variety of grains with a metallic aspect and of a light, black residue resembling coal dust. A vein-like mass some three millimeters thick, that showed through the rust crust with the appearance of the pencil-like inclusions of troilite in the Bendegó meteorite, extended for about a centimeter into the mass and not being acted upon by the acid, came away in fragments. After fourteen weeks of treatment with frequent changes of acid, the action almost ceased although a considerable mass still remained undissolved. This had much the shape and appearance of the original meteorite though much more irregular and jagged, and represents a nucleal portion less soluble than the generality of the mass.

The undissolved residue was separated by screening through fine bolting cloth, sorting under the lens, and with a magnetized knife point, into the following groups: vein matter consisting

*I was also shown in Washington schistose masses of iron oxide found in the same region, whose connection with the meteorite was considered doubtful. These closely resemble the thicker masses of rust crust formed on the Bendegó meteorite and like it, as is well seen in sections prepared by Mr. Diller, show minute particles with a metallic luster which are almost certainly grains of schreibersite, as that mineral has been separated from the rust crust of both Bendegó and São Francisco do Sul. In view of its occurrence it can hardly be doubted that these Canon Diablo specimens are due to secondary alteration of the meteorite. As the iron masses in general have only a thin rust crust, indicating considerable resistance to oxidation, it may be suggested that these thicker masses of oxide may perhaps come from original pyrite as in the case of São Francisco do Sul.

of massive schreibersite with cohenite; irregular jagged fragments resembling the large nucleal piece and bristling with needles of rhabdite (*zackige Stücke* of Cohen?); taenite; coarse schreibersite and cohenite from the general mass and not from the vein (a considerable part of the schreibersite was free but the grains of cohenite were so charged with it that no satisfactory separation of the two could be effected); fine magnetic residue for the most part schreibersite in the form of rhabdite needles but with fine particles of taenite; granular schreibersite and cohenite, and a black, coal-dust-like residue highly charged with rhabdite. The separation could not be completely made except for the jagged pieces and coarser taenite, schreibersite and cohenite. In the finer material the two last were so lumped together that neither by sorting nor by gravity or magnetic methods could they be satisfactorily separated. An attempt to separate the light, coaly matter by the use of the Thoulet solution was only partially successful, as a small amount of the black particles were carried down with the heavy metallic grains and a larger portion of these were retained by the spongy, coaly particles. The proportions given below, calculated for the dissolved portion after deducting the nucleal piece and the vein matter, are therefore only approximate.

Original specimen	195 grams	
Large jagged nucleal piece	9·1855	
Vein matter, schreibersite and cohenite	2·971	
Small jagged pieces	1·4105	0·78%
Taenite	1·872	1·02
Coarse schreibersite and cohenite	7·5835	4·14
Fine magnetic residue mainly schreibersite, in part acicular (rhabdite), with some taenite and cohenite	1·4945	0·82
Fine non-magnetic residue with rhabdite	0·517	0·28
Dissolved	169·966	92·95
		100·00

An analysis of 100cc of the solution corresponding approximately to 0·5 grams of the meteorite (except for the copper determination which was made with 500cc) gave:

Fe	91·264%
Ni and Co	8·252
P	0·440
Cu	0·044
	100·000

This result agrees fairly well with the composition of kamacite (Fe 93·11, Ni and Co 6·89) according to the formula $Fe_{11}Ni$

as given by Cohen. As the proportion of phosphorus and copper is higher than in the greater part of Cohen's analyses* in which for the most part weaker acid was employed, it may be presumed that the elements rich in nickel, taenite, schreibersite and the coaly substance, were more strongly attacked, giving an enrichment in nickel. Making allowance for this circumstance, the dissolved portion may be considered as consisting essentially of normal kamacite.

The large jagged piece which was only attacked with extreme slowness by cold acid of a strength of 1 to 10 was tried with acid 1 in 5 without much better results in the cold. On heating on the water bath vigorous action commenced and continued even after the acid was much diluted. At times the action would continue in the cold after removal from the bath, at others it would almost cease in the hot acid and only recommence with vigor on the addition of a considerable quantity of fresh acid. At other times the action would continue until the acid was completely exhausted and a precipitate began to appear in the solution. These variations in the action of the acid indicate a lack of homogeneity and varying degrees of solubility in different parts of the mass. The residue was similar to that of the original mass except that cohenite was almost entirely lacking. The principal contrast in the two residues was in the greater relative abundance of rhabdite and the less abundance of granular schreibersite and of the coaly matter in that of the jagged piece. The coaly matter was evidently partially destroyed by the action of the hot acid and the residue was entirely freed from it by treatment with strong, cold acid, a white flocculent skeleton remaining.

The large piece was broken up as follows:

Original specimen		9·1855 grams	
Taenite		0·029	0·31%
Schreibersite	granular 0·0075 0·08%	0·033	0·35
	acicular 0·0255 0·27		
Non-magnetic residue		0·325	0·34
Dissolved		9 094	99·00

An analysis of the solution gave the following result (copper was determined in the whole solution, the other elements in 100cc:)

Fe	94·32
Ni and Co	5·78
P	0·15
Cu	0·05
	100·30

* Annalen d. K. K. naturhistorischen Hofmuseums, vi, 1891, p. 131; vii, 1892, p. 143; ix, 1894, p. 97.

This composition agrees very nearly with that of the "zackige Stücke" of Toluca given by Cohen, and like that shows a higher proportion of iron and a lower proportion of nickel and cobalt than the general mass of the meteorite and of normal kamacite. The occurrence of rhabdite is not noted in the case of Toluca but may perhaps be presumed from the relatively high percentage of phosphorus.

The non-magnetic residue consisted mainly of rust particles and some dirt evidently derived from laboratory dust. Nothing of any interest that could be referred to the meteorite could be detected in it by microscopic examination.

The small jagged pieces were dissolved in copper-ammonium chloride with the view of determining the amount of carbon but owing to an accident this determination was lost, and only the relative proportion of granular (1·84 per cent) and of acicular (1·16 per cent) schreibersite was determined. The amount of the coaly residue was apparently greater than with the treatment with acid. The higher proportion of schreibersite may be referred in part to the slighter action of the solvent, by which more of the original content is recovered, but it is also evident that this mineral, particularly in the acicular form of rhabdite, is more abundant than in the generality of the meteoric mass.

An analysis of taenite, which was dissolved in copper-ammonium chloride, gave:

Schreibersite	1·65
Fe	66·46
Ni	30·28
Co	0·68
Cu	0·32
P	0·30
	99·69

In composition as well as in physical aspect (thin, tin-white flexible lamellæ) this agrees very closely with the group rich in nickel and free from carbon of Toluca, Wichita, etc. as given by Cohen. With Toluca also it agrees in the presence of a determinable amount of copper. The phosphorus of the above analysis indicates, as Prof. Cohen has already remarked, that schreibersite is not wholly insoluble in the Cu-Am chloride.

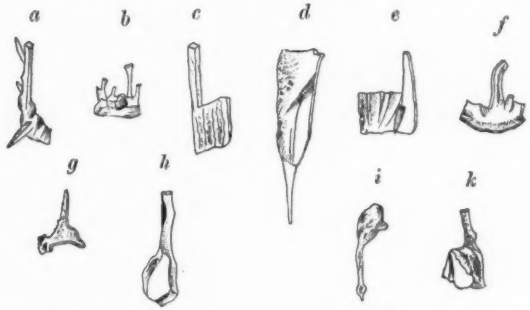
Two analyses of cohenite were made, No. I being the free grains from the general solution of the mass and No. II the vein matter. Both were dissolved in copper-ammonium chloride and the percentages calculated for the difference in weight after deducting the considerable residue of undissolved

schreibersite, separated with the magnet from the carbon, which was determined by burning in a stream of hydrogen and weighing as carbonic acid.

	I.	II.
Fe	92·88	91·67
Ni and Co	1·33	2·43
P	0·48	0·09
C	5·33	6·07
	100·02	100·26

The phosphorus is undoubtedly due to a slight action of the solvent on the schreibersite, which as already remarked is not wholly insoluble in copper-ammonium chloride. This result agrees very well with the analyses of cohenite given by Weinschenk and Cohen and with an unpublished analysis of that of Bendegó by Dafert. In appearance the cohenite grains agree with those of Bendegó although they are richer in inclusions of tabular schreibersite. Owing to the general distortion of the crystals and the rounded character of the faces, no measurements could be made, but the forms are undoubtedly identical with those of Bendegó, on which Hussak succeeded in demonstrating that they belong to the cubic system.

Three distinct forms of iron and nickel phosphide occur which although differing greatly in appearance and somewhat also in chemical composition, are probably different phases of a single mineral species. The most abundant individually are the acicular forms known as rhabdite, though, owing to their minute size, they do not equal in weight the granular and



tabular forms known as schreibersite. Both are generally distributed throughout the mass, the schreibersite form being particularly abundant, included in, or adherent to, the surface of the cohenite grains, while the rhabdite needles are especially concentrated in the less soluble metallic portions and in the

spongy, coal-like particles. Both are distinctly crystalline and, as shown in the annexed figure, may occur in the same individual. As Cohen has already shown the chemical identity of the two types, no further proof seems necessary that schreibersite and rhabdite belong to the same mineral species, for which the former name, being the older, should be retained. Diligent search was made without success for crystals that would admit of measurement, the rhabdite individuals being too minute and those of the schreibersite type too much distorted and with strongly rounded faces. The general appearance of the latter type is strongly suggestive of distorted crystals of the cubic system, while the rhabdite needles are apparently tetragonal prisms, although they might also be distorted members of the cubic system. On crystals which will be described later, separated from the São Francisco do Sul mass, Dr. Hussak succeeded in proving that the crystalline form of schreibersite is really tetragonal.

The third form of phosphide occupies the center of the vein mass being enclosed between walls of cohenite. This is massive and extremely brittle, breaking with a conchoidal fracture and in color and general appearance strongly resembling arsenopyrite.* As shown by the analysis below (No. III) the composition differs from that of the typical schreibersite of the same meteorite in the relative proportions of the iron and nickel. The phosphorus is also higher in the complete analysis and approaches more nearly to what Prof. Cohen considers as the normal proportion, but in a separate determination (No. IV) the proportion is nearly the same as in the normal granular schreibersite with a slight admixture of rhabdite needles, Nos. III and IV of the vein matter. In all the material was freed from taenite and cohenite by treatment in copper-ammonium chloride, and in No. II special care was taken in the washing to make sure that the copper found in I and III previously executed, really belonged to the substance and did not come from this solvent.

	I.	II.	III.	IV.
P	12·82	13·17	14·58	12·98
Fe	54·34	51·25	66·72	
Ni	31·48	33·68	17·54	
Co	0·67			
Cu	0·20	0·17	0·13	
Sn		1·18	tr.	
	99·45	99·45	98·97	

* The cohenite of the walls of the vein also forms a massive crust covered however with crystalline faces on its outer surface.

The most reliable published analyses of meteoric phosphide, or phosphides, show very variable relative proportions of iron and nickel and cobalt even in the same meteoric mass and as regards phosphorus, a larger group with about 15 to 16 per cent and a small group with about 12 to 13 per cent. The above analyses place Cañon Diablo in the latter group. Copper is only reported in two, Schwetz and Seeläsgen, both of which have been reanalyzed by Cohen with very different results and without copper, which possibly, however, was not looked for. Tin has not been reported, possibly because the solution has usually been made in aqua regia in which it would only appear through a special research. In the present case the solution was made in plain nitric acid and the tin appeared as oxide and was verified by blowpipe tests. The proportion in No. III was certainly as great as in No. II, but was not determined for fear of losing the slight residue before a qualitative test could be made. Curiously enough it did not appear in Nos. I and IV, possibly from the accidental presence of enough chlorine in the nitric acid to dissolve the small amount of stannic oxide as fast as it formed. If this was not the case, it must be presumed that the tin does not belong to the schreibersite but to another mineral that is not generally distributed throughout the meteoric mass, so that it only appears in certain portions of the residue.

As in the course of this investigation, which was mainly undertaken for the purpose of verifying the reported existence of the diamond in the Cañon Diablo meteorite, nothing resembling that substance, or any other form of free carbon, could be detected, it was suspected that possibly the polishing effect produced by the residue of the dissolved mass and attributed to the presence of diamond dust might be due to schreibersite. Owing to the minuteness of the grains and their extreme brittleness, it is difficult to determine the hardness accurately and the figures given (7·01 to 7·22) may be too low. The means at hand were too crude for an accurate test, but apparently distinct scratches were produced on a cleavage plane of topaz and a depolishing effect on the polished face of a cut sapphire. Specimens have been submitted to Mr. George F. Kunz with a request to test the hardness with more perfect appliances, and probably he will report upon them.

The non-magnetic residue consisted for the most part of irregular, black, coke-like particles full of needles of rhabdite. These dissolve quietly in strong hydrochloric acid, setting free the crystals of rhabdite. In strong nitric acid under the microscope there is a rapid evolution of gas that tears the particles to pieces, scattering the rhabdite and leaving an extremely light, whitish flocculent skeleton.

In the following analysis this coaly residue was treated with strong nitric acid for a few minutes until the black color disappeared and an attempt was made to collect the escaping gas. As, however, abundant red fumes appeared, it was concluded that the gas came from the acid and it was allowed to escape. The great deficiency in the following analysis indicates, however, that a gaseous constituent may have been set free from the substance. The heavy residue was separated by decantation and divided with the magnet into rhabdite and a non-magnetic portion consisting of rust particles and grains of sand evidently from laboratory dust, or dirt on the original rust covered surface of the meteorite. Nothing of interest that could be referred to the meteorite could be observed in it under the microscope. The light, flocculent residue collected on an asbestus filter was burned and determined as carbon by collecting and weighing the gas given off. The other constituents were determined in the nitric acid solution. The numbers given below can only be considered as approximative, as the separation by decantation may not have been complete and there may have been some loss in the mechanical separation of the heavy residue. Still after making all due allowances for defects in the process of analysis, the deficiencies are too great to be accounted for in this manner and must be attributed to one or more undetermined constituents, possibly gaseous. The result obtained is as follows:

Fe	7·11
Ni and Co	37·47
Cr	tr.
Cu	2·84
P	0·88
C	5·60
Rhabdite	11·65
Non-magnetic residue	8·30
	68·30

The phosphorus can probably be referred to a partial solution of the rhabdite and the traces of chromium may perhaps indicate an admixture of daubréelite. The whitish flocculent substance giving carbonic acid on burning is very extraordinary, though something similar seems to have been observed by Tschermak (as quoted by Flight, History of Meteorites, p. 163,) in the Goalpara meteorite. As a similar residue with the same aspect and behavior with acids and with a strong nickel reaction in the borax bead was obtained in small quantities from Bendegó, efforts are now being made to obtain a sufficient amount for a more careful study of this curious substance.

The non-magnetic residue of the above analysis contained all the non-soluble and non-magnetic residue of the original mass treated, together with all the dirt accumulated throughout the long process of treatment. Nothing of interest that could not be referred with almost absolute certainty to the later source could be observed in it in a careful microscopic examination. Evidently the mass treated did not contain diamonds or anything remotely suggestive of them.

ART. X. — *β-Bromvalerianic Acid, CH_3-CH_2-$CHBr$-CH_2-$COOH$;* by JOHN G. SPENZER, Cleveland, O.

THE first step in the preparation of β-bromvalerianic acid was the preparation of propylideneacetic acids by the action of hot, caustic soda solution on ethylidene propionic acid.

To one volume of pure propylideneacetic acid contained in a small cylinder having a well ground stopper, 1½ volumes of hydrobromic acid saturated at 0° C. were added, on shaking a clear solution resulted, it was allowed to remain quietly for 24 hours at the ordinary temperature; the monobromide had now risen to the surface of the hydrobromic acid as a light brown colored layer. The cylinder was now vigorously shaken from time to time, to bring any unaltered propylideneacetic acid, which might be dissolved in the monobromide into intimate contact with the hydrobromic acid. After this occasional shaking had been continued for four or five days, the contents of the cylinder formed two distinct layers, the reaction was ended and all the propylideneacetic acid had been quantitatively changed into β-bromvalerianic acid. The cylinder still stoppered was now placed in ice water, to cause the new acid to solidify, this, however, did not occur; it was then placed in a freezing mixture of ice and salt, and on agitating slightly the monobromide at once congealed to a solid mass of fine needles lying on the surface of the hydrobromic acid. The cylinder stood for 15 hours at a temperature of 15° C.; then the crystalline cake was broken through with a glass rod, distributed through the hydrobromic acid and brought into a platinum cone, where it was allowed to dry, being washed with small successive portions of ice water, in order to remove the greater part of the mineral acid.

The contents of the cone were now brought on to a watch glass and placed in a vacuum over sulphuric acid and caustic potassa; a dry sandy, white substance resulted, which was powdered and recrystallized out of petroleum ether. So produced, the β-bromvalerianic acid is, after drying, perfectly pure, as the analysis proves:

0·233 g. of the substance dried in a vacuum gave 0·2410 Ag Br.

Calculated for $C_5H_9BrO_2$.	Found.
44·20% Br.	44·20% Br.

β-bromvalerianic acid melts at 59° to 60° C., the melting point not altering in the least by repeated determinations on the same sample. It dissolves readily in ether, chloroform, carbon disulphide, less easily in benzene and petroleum ether, and is almost insoluble in water of 0° C. If the cold, saturated solution of the monobromide in petroleum ether be allowed to evaporate spontaneously it crystallizes out in beautiful, colorless, 8-sided prisms.

The crystals set up after Naumann's System give the following crystallographic measurements:

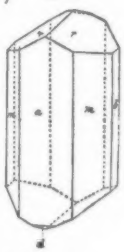
β-Bromvalerianic acid.

Crystal system: Monosymmetric.

$\dot{a} : \overline{b} : \dot{c} = 1{\cdot}4688 : 1 : 0{\cdot}4900$

$\beta = 79° 58' 45''$

Observed forms: $m = \{110\} \infty P$, $a = \{100\} \infty P\infty$, $b = \{010\} \infty P\infty$, $r = \{011\} P\infty$, $d = \{\bar{1}01\} + P\infty$, $e = \{101\} - P\infty$



The crystals are mostly 2 to 5mm long by 1 to 2mm wide and possess a valerianic acid like odor.

Some crystals are without $\{\bar{1}01\} + P\infty$, as also $\{100\} \infty P\infty$, while $\{101\} - P\infty$ was only observed once.

The faces were almost always smooth and polished giving excellent reflections.

The following angles were measured and calculated:

		Measured.	Calculated.
$r : r$	$= (011) : (011) =$	*51° 31′	------
$a : m$	$(100) : (110)$	*55 21 30″	------
$r : m$	$(011) : (\bar{1}00)$	*99 1	------
$m : m$	$(110) : (1\bar{1}0)$	110 43	110° 41′
$m : b$	$(110) : (010)$	34 47	34 39 30″
$r : b$	$(011) : (010)$	64 6	64 14 30
$a : b$	$(100) : (010)$	89 58	90
$a : d$	$(100) : (\bar{1}01)$	99 2	99 12
$r : m$	$(011) : (1\bar{1}0)$	74 2	74 26
$a : e$	$(100) : (101)$	61 59	62 44
$r : d$	$(101) : (\bar{1}01)$	36 33	36 29
$r : m$	$(011) : (110)$	63 33	63 28
$r : d$	$(011) : (\bar{1}01)$	31 8	31 45
$d : m$	$(\bar{1}01) : (\bar{1}00)$	80 11	80 48

The plane of the optical axes stands at right angles to the clinopinacoid and is only slightly inclined towards the orthopinacoid.

A cleavage could not be found. Obtuse bisectrix = $\overline{b}$ axis.

Art. XI.—*The Inner Gorge Terraces of the Upper Ohio and Beaver Rivers;* by R. R. Hice.

In all discussions of the terraces of the upper Ohio region a sharp distinction has been drawn between the Upper Rock benches, and the terraces lining the inner gorge, first, in the character of the alluvium connected with each and, secondly, in their structure.

The alluvium of the Upper Rock bench on the Beaver river (below the glacial boundary), consists of clayey deposits, with occasional pockets of gravel. On the Ohio, above the mouth of the Beaver, the proportion of gravel is greater, but below that stream the deposits partake more of the clayey character, reaching however a much greater thickness than is generally found on the Beaver.

The alluvium of the inner terraces, on the contrary, is almost entirely gravel, with a large proportion of metamorphic material, with its immediate origin in the morainic deposits a few miles northward. It cannot be mistaken for, or confused with, the gravels found on the higher benches, from which it is distinguished (1) in the character of its deposition, (2) in the proportion of metamorphic material, (3) in the shape of the pebbles, (4) in the apparent greater age of the higher gravels. These distinctions when once noted are not easily mistaken, and taken together form a certain guide, irrespective of difference in elevation above present stream level.

The distinguishing feature of the upper terraces is the ever present rock shelf. Prof. White in speaking of the most prominent of the upper terraces says a rocky escarpment leads up to at every point where it is seen.* In point of fact, the true character of the upper terraces has been generally recognized, in that they represent fragments of the bed of the stream, left in the original excavation of the valley. They are thus the earliest records we have of the cutting stream, and evidence has been heretofore presented, both of a general and local character, to show that the original stream flowed to the north, and has been reversed.

On the other hand, it has been assumed heretofore, that the distinctive mark of the terraces of the inner gorge was the absence of any included rock shelf. This assumption presupposes that the inner gorge differs from the upper, wider, and older valley, in its freedom from any remnantal benches, and from their supposed absence it has, in turn, been assumed that the cutting of the inner gorge was a short, quick, continuous

*For principal papers relating to subject, see list at close of paper.

action; that, when renewed activity had been given the cutting stream, excavation proceeded without break, until the bottom of the now buried channel was reached. A more careful examination of the inner terraces shows, however, that to some extent at least, the prevailing notions regarding them are not correct. There are points, it is true, where the current descriptions seem, in some features, entirely accurate, but it is believed that sufficient is now known to show that the broad generalizations that have been drawn are incorrect.

Passing up the Ohio from the Pennsylvania and Ohio State line, the inner terraces alternate from side to side of the stream, and no appearance of an included rock shelf has been noticed until Raccoon Creek is reached. On this part of the Ohio the inner terraces, so far as observed, are made up bodily of alluvium, the gravel appearing to extend from the top of the terrace to the bottom of the now buried channel.

At the mouth of Raccoon Creek we find the alluvium reaching to the height of the "third" terrace (about 120 feet above river level) and along the river front it presents an unbroken escarpment of gravel and bowlders. Raccoon Creek, which is quite a rapid stream, shows, however, that the apparent uniformity in terrace material is a mistake. As this stream emerges from the narrow valley it has cut for itself, into the trough of the Ohio, we find it does not follow its natural course, but, turning abruptly up the larger stream, it has cut for itself a narrow cañon through a rather massive sandstone. The direct course of the stream we find cut off by the alluvial deposit, and evidently the old channel of the creek, which was cut when the now buried channel of the Ohio was being excavated, was, on the coming of the alluvium, filled to the terrace level, and when the Ohio re-excavated its channel in the gravel, Raccoon Creek was turned in its new course and has cut the channel we now find, which is in no way comparable in size with the valley cut for many miles by the same stream. How far the rock here underlying the terrace extends we have yet no means of knowing.

Crossing the Ohio to the next fragment of inner terrace we come to the point where the inner terraces have their greatest development on the upper Ohio. On both sides of the Beaver river the terraces attain a height of one hundred and twenty feet above stream level. On the lower, or Beaver, side it extends from a point about two miles below the mouth of the Beaver up the Ohio, and thence up the Beaver for about one mile. Where Two Mile run cuts across the terrace a modern channel has been cut through the ferriferous limestone, which here underlies the terrace in a broad, flat bench. How far this rock bench extends cannot be told. It at no point shows on

the escarpment of the terrace, and wells have been sunk at Beaver, one mile up the stream, that reach river level without finding rock. It may be, however, these wells lie in the course of the buried channel.

Two hundred yards from the mouth of the Beaver we find that stream flowing over the soft shales that overlie the Homewood sandstone. Of the extent of this bench, which here lies at stream level, nothing is known. On the eastward a rock escarpment cuts it off, to the west it is covered with alluvium. Towards the Ohio it is cut off by the buried channel of that river, and up the Beaver it is covered by the impounded waters of that stream. It seems most probable, however, that it is but a small, triangular bench, lying between the buried channels of the Ohio and Beaver rivers and the rock escarpment, here rising on the eastern bank of the Beaver.

On the eastern bank of the Beaver, at Rochester, the rock is seen passing under the higher portion of the terrace. The Rochester terrace is triangular in shape, bounded by the Ohio and Beaver rivers on the two sides, and the bounding hill of the valley on the northeast. The face of the escarpment along the Ohio has been cut by the railroad and no rock is seen. It is impossible therefore to assign any dimensions to the rock shelf seen on the Beaver side.

Passing up the Ohio we find a rock bench showing along the railroad cut below Baden and extending, almost continuously, to Legionville. Here the rock shelf is plainly visible, and even in a cursory examination it is evident that, measuring from the bottom of the buried channel, almost the whole terrace is rock in place.

The terrace at Economy, extending from Legionville to the Allegheny County line, has long been considered entirely gravel. Wells have been sunk at the town of Economy to river level without finding rock, yet a short distance below the town a quarry has been worked, right on the escarpment of the inner terrace. Of the extent of the rock shelf we have yet no means of knowing.

Returning to the Beaver and passing up that stream, we first come to a small rock bench about twenty-five feet above stream level, occurring at the mouth of Brady's run. This stream at its mouth, is now flowing in a rock channel, while a half mile up the stream it has a buried channel fifty feet, or more, in depth. The old channel evidently passed into the Beaver higher up that stream, and the present channel is a post terrace one.

Passing up the Beaver to the upper end of Beaver Falls, we reach a point where the Beaver, passing out of the narrow gorge in which it is confined for some eleven or twelve miles,

flows in a modern channel for about two miles. From records it is known that the buried channel passes to the westward of the present stream in a long curve and is crossed by the present river, nearly at right angles, about one and a half miles below, thence the buried channel, now passing beneath New Brighton, makes a sweep to the right and the present channel passes into it a half mile further on.

The modern channel, from where it leaves the old one, at the upper end of Beaver Falls, flows in a shallow trough, cut in a rock bench left in the original cutting of the inner gorge, and this modern channel represents the post-terrace work of the Beaver. This stretch of the Beaver presents, in many respects, the best place to study the inner rock benches, for a rock escarpment is present for much of the distance. On the New Brighton side, from the point where the new channel enters the buried one, rock is seen in a low shelf extending under the inner alluvium and reaching to the point where the old channel is crossed by the modern one. Above this point the river runs close to the hill bounding the valley on the east, until Eastdale is reached, at the upper end of the modern channel, where quite a large shelf is seen, extending under the whole of the inner terrace at that point. On the western side of the stream, passing upwards, we find a rock bench, corresponding to the one at New Brighton. It occupies the triangle lying between the present stream, Walnut Bottom Run, and the western bounding hill, having a frontage of about one-fourth mile on the Beaver and one-half mile on the Walnut Bottom Run side. About one-half mile above the mouth of Walnut Bottom Run rock is again seen in place, extending continuously to the point of junction with the buried channel. This shelf is nowhere seen on the Walnut Bottom Run side, but is well defined by wells, and is known to extend about one mile in a southwesterly direction, being but a few feet below the surface until Twelfth Street is reached, from which point it falls rapidly, owing to the proximity of the buried channel.

In the narrow gorge which extends from Beaver Falls to Wampum, it was not expected that any fragments of inner rock benches could be found, but an examination of the gravel deposit at Clark's Run (Homewood) shows that it is resting on a rock bench. In changing the line of the P. & L. E. R. R. it was thrown into the hill, and the necessary cutting disclosed a bench consisting of the soft shales underlying the Homewood sandstone.

Passing out of the narrow gorge at Wampum, we have passed into the glaciated region, and the inner benches are somewhat harder to trace. The character of the inner gorge also changes, becoming wider than at any point below. This

is due to the character of the strata cut, here being much softer than below where the gorge is cut in hard sandstones.

A short distance above Wampum a bench is seen, extending some distance, and, crossing the river to Moravia (east side), a corresponding bench is seen. The river at this point makes a sharp reverse curve, cutting from side to side of the valley, so that these two benches are really one, cut across by the river. The bench at Moravia reaches well to the confluence of the Shenango and Mahoning rivers.

Along the Mahoning river rock in place is frequently seen, and some of the inner terraces are undoubtedly of this character. The same is true of the Shenango valley, but neither of these streams have yet been studied or mapped.

A glance at a map will show we have followed the Ohio river from the Ohio and Pennsylvania line to a point but fifteen miles below the confluence of the Allegheny and Monongahela rivers, a distance of twenty-four miles, and the Beaver river its entire length, a distance of twenty-two miles. The following table gives the terraces on the rivers studied and the occurrences of rock where noted above. The flood plain is not given except where underlaid by rock.

On the Ohio.

Georgetown,	south side river,		No rock observed.
Below Industry,	north side river,		" "
" "	south "		" "
Above "	north "		" "
Raccoon Creek,	south "		Underlaid by rock.
Beaver,	north "		" "
Bridgewater,	" "		" "
Rochester,	" "		" "
Monaca,	south "		No rock observed.
Baden,	north "		Underlaid by rock.
Aliquippa,	south "		No rock observed.
Economy,	north "		Underlaid by rock.
Shannopin,	south "		No rock observed.

On the Beaver.

Brady's run,	west side river,		Underlaid by rock.
Fallston,	" "		No rock observed.
New Brighton,	east "		Underlaid by rock.
Beaver Falls (1),	west "		" "
" " (2),	" "		" "
Eastdale,	east "		" "
Homewood,	west "		" "
Wampum,	" "		" "
Moravia,	east "		" "

It will be noticed there are twenty-two observed terraces, and of these fourteen are underlaid by rock benches, to a

greater or less extent. The first four, and those of Monaca, Aliquippa and Shannopin are not favorably situated to show the presence of an included rock shelf; no stream cutting them in such a way as to reveal their structure.

It has not been possible in all cases to assign even approximate limits to the observed rock benches. At Raccoon, Beaver, Rochester and Economy it is evident they underlie but a portion of the terrace and there is as yet no data that will enable any estimate of proportion of included rock shelf to entire terrace to be made. At New Brighton the rock extends only under the lower terrace, and whether it underlies more than that portion of the terrace lying between the buried and modern channels of the river has not yet been determined. At Beaver Falls the limits of the rock are well defined, and estimating from the bottom of the buried channel, one-half of the whole terrace would seem to be rock. At Eastdale the rock rises practically to the surface, and fully nine-tenths of this fragment is rock. At Homewood the rock underlies the whole of the gravel deposit and constitutes one-half of the whole (the gravel here rising to the level of the outer rock bench). At Wampum the greater portion of the terrace seems to be rock. The shelf shows for some distance along the river front and rises almost to the level of the terrace, which is also true at Moravia. In the terrace extending from Baden to Legionville the railroad cutting shows rock reaching practically to the surface and constituting at least four-fifths of the entire terrace.

It will thus be seen that the data for forming an estimate is not sufficient to judge accurately, yet it must be evident that the included rock benches form no insignificant portion of the inner terraces, and reduces by that amount the immense quantity of alluvium which it has been supposed made up the terraces. From the present data the writer believes the proportion of rock will be found over, rather than under, one-half of the entire volume of the terraces, measured from the bottom of the buried channel.

The attempt to correlate the rock benches has not been entirely satisfactory. Taken as a whole the benches on the Beaver (Moravia, Wampum, Homewood, Eastdale, Beaver Falls, New Brighton) lie at about the same elevation above present stream level (30′ to 40′). The benches on the Ohio (Economy, Baden, Rochester, Beaver, Raccoon) lie at a somewhat higher elevation above stream level (50′±), yet it seems they belong to the same series found on the Beaver. The Ohio is flowing over its buried channel in this region and has eroded its post-terrace channel deeper than the Beaver, which has been cutting a new rock channel within about two miles of its mouth, and that through the hard Homewood sandstone.

This view of the benches is in harmony with the facts as shown on the Beaver. The rock benches at Beaver Falls and New Brighton, where the Beaver is cutting its new channel, lie nearer stream level than the benches at Wampum and Moravia, where the Beaver is re-excavating its buried channel. It may also be added that the greatly increased fall of the Beaver in the last four miles of its course where it drops down from the rock channel into its buried one, and thence into the Ohio, is sufficient to compensate for the greater elevation of the benches on the Ohio.

It would seem therefore that sufficient is now known to justify the conclusion that the cutting of the inner gorge is to be subdivided into two periods. (1) The time required to cut from the level of the lowest of the upper rock benches to the level of the inner rock benches, when erosion seems to have approached a base level, and (2) a second period of cutting from the inner rock benches to the bottom of the buried channel. The first period evidently much the longer. The bench at Homewood, for example, is some seventy feet above the bottom of the inner gorge (the bottom of the buried channel), and about one hundred feet below the lowest of the upper benches. The work of erosion in the first period was here through the Homewood sandstone in great measure, while the cutting of the second period was in shales to a great extent; the lower portion of the gorge is also narrower than the upper portion. It seems safe to say, therefore, the first period represents two-thirds to three-fourths of the entire work of excavation, and probably a larger proportion in time.

After the excavation of the buried channel, the next chapter of the river history was the silting of the valleys to the top of the inner terraces. It is not purposed in this paper to discuss the inner alluvium, further than to call attention to a mistake regarding it, evidently due to a study of the gravel escarpments, without examination of the structure back from the face. It has been described as quite coarse, ranging up to two feet in diameter, and the impression prevails that it is uniformly of this character, from top to bottom, and from escarpment to the base of the hills bounding the inner gorge.

It seems evident, and generally admitted, that the alluvium should be considered as a whole, from the top of the highest terraces, to the bottom of the buried channel. The records that determined the existence of the buried channel were not sufficient to furnish any knowledge of the character of the filling, and it is only recently any real knowledge has come to light, and rendered it possible to form a correct idea of the filling material and consequently of the stream that deposited it.

The writer has records, more or less complete, at four points, one on the Ohio and three on the Beaver. The first of these is at Dam No. 6 (Merrill) on the Ohio, near the mouth of Raccoon Creek. This set consists of a series of drill holes in a line across the river, at regular intervals of one hundred feet. Only two holes reach bed rock, one hundred and two hundred feet respectively from the northern bank of the river. All the other holes are deeper, but in no case reach rock. In all cases after passing through the immediate bed of the stream, the alluvium is much finer than shown by the escarpment of the terraces.

The next record is at the mouth of Wallace's run. No accurate records of strata are at hand, if indeed any were kept, but it is well established that in passing through the 60′ of alluvium the material grew successively finer, and about twenty feet of it, immediately overlying the rock bottom, consisted of a very fine silt.

The third set of soundings reach rock in all but one hole, and consist of test wells sunk to determine the foundation for piers, about one-half mile below the mouth of the Connoquenessing. The records of all these wells agree and it is possible to form from them an accurate knowledge of the stratification of the filling of the buried channel at that point. Three distinct strata are recognized, the top of each horizontal, and conformable to each other, but non-conformable to the rock bottom on which they lie. Immediately overlying the rock bottom is a layer of fine silt, reaching in the middle of the channel a thickness of twenty-five feet, but thinning out to nothing on the sides. The top is horizontal and the thinning at the sides is due entirely to the rising of the rock bottom. Overlying the silt is a fine sand, eight to ten feet in thickness This also abuts against the rock at each side. Overlying this in turn is a fine gravel. The top of this stratum has been slightly eroded by the present stream, but it lies conformably on the sand stratum. Over the gravel is a thin deposit of river detritus.

The last of the records is at the railroad bridge between Wampum and Moravia. This set is incomplete, as the wells do not reach rock, but as far as they go they entirely agree with the others in the successively increasing fineness of the filling material, from the surface downward.

It should also be said that in a number of excavations about Beaver Falls and New Brighton "quicksand" has been frequently reported, and it is recognized by all persons conversant with deep excavations in the buried channel, that the material grows finer as excavation proceeds.

If we examine the structure of the terraces as revealed by excavations in the midst of them, we find them in harmony with the character of the filling of the buried channel. A well at Beaver Falls commenced at the top of the terrace, and excavated over eighty feet to rock, showed first a few feet of coarse material, followed by coarse gravel, which in turn grew finer until it corresponded with the gravel found in the buried channel. At Beaver, after passing through a few feet of the coarser material, the same is true, reaching, as we know from old wells, to the present level of the Ohio. At Georgetown, after passing through eight feet, no more "bowlders" were found to present river level.

It is not intended to convey the impression that the terraces, or rather the alluvial portion of them, are made up bodily of the finer material, for it is believed there are evidences from the escarpment that in the middle of the valleys the upper half of the filling is coarser than the average, but it is evident the stream depositing the alluvium had by no means the transporting power heretofore assigned it. In the refilling of the inner gorge the depositing stream was not a torrential current, but at first was quite sluggish, depositing fine silt only, gradually increasing in carrying power until the whole of the inner alluvium was deposited, but apparently at no time of sufficient eroding power to remove the deposit just previously made.*

Beaver, Pa., Jan. 5, 1895.

*The literature of subject is quite scattered, the principal papers are:—
T. C. Chamberlin, U. S. Geol. Survey, Bull. 58, pp. 24–37; Bull. Geol. Soc. A., vol. i, pp. 472–473; p. 479; this Journal, vol. xlv, p. 195; vol. xlvii, p. 247. G. F. Wright, U. S. Geol. Survey. Bull. 58, pp. 76–78, pp. 81–86; Ice Age in N. A., pp. 287–289, pp. 335–339; this Journal, vol. xliv, pp. 368–371; xlvii, p. 161; Am. Geol., vol. xi, pp. 195–199. Dr. Alfred T. King, "Ancient Alluvium of the Ohio Valley and its Tributaries," January, 1854. Frank Leverett, this Journal, vol. xlii, p. 210; vol. xlvii, p. 247. P. Max Foshay, this Journal, vol. xl, p. 401; Bull. G. S. A., vol. ii, p. 457. I. C. White, Second Geol. Survey Penna., vol. Q, pp. 10–14; vol. QQ, pp. 10–12; vol. QQQ, pp. 17–18. J. J. Stevenson, Second Geol. Sur. Penna., vol. K, pp. 11–19. J. P. Leslie, Sec. Geol. Sur. Penna., vol. Q, pp. xxv. B. C. Jillson, Trans. of Academy Sci. and Art. Pittsburg, vol. i, pp. 1–25. E. W. Claypole, Trans. Geol. Soc. Edinburgh, 1887, p. 42. R. R. Hice, Bull. Geol. Soc. Am., vol. ii, p. 457; Science, vol. xxii, p. 170.

Art. XII.—*The Glacial Land-Forms of the Margins of the Alps;* by Hugh Robert Mill.

[From the Geographical Journal, January, 1895.]

At the close of the sixth meeting of the International Geological Congress, which was held at Zurich during August and September, an excursion occupying a week was arranged in order to afford an opportunity of examining the remains of ancient ice-action far beyond the reach of actual glaciers on both the southern and northern slopes of the Alps. This trip was planned and directed by Professors Penck and Brückner and Dr. Du Pasquier, who, from their previous knowledge of the localities to be visited, had drawn up a guide in the form of a pamphlet of 86 pages, entitled "Le Système glaciaire des Alpes," which is published in vol. xxii of the Bulletin of the Neuchâtel Society of Natural Sciences.

The special object was to exhibit the part played in the formation of the land surfaces at the base of the Alps by the moraines or glacial formations, strictly so called, of the great Ice Ages, and also of the intermediate fluvio-glacial deposits of moraine material which had been rearranged by water on the retreat of the ice. To these was added involuntarily, rather too much experience of the "pluvio-glacial" conditions which several days of steady rain at the beginning and at the end of the excursion induced on the steep surfaces of the clay slopes over which Professor Penck led his followers.

The main point of interest to the glacial geologist was the proof afforded by the sections of the occurrence of at least three successive periods of great glaciation separated by relatively long intervals, during which the vast volumes of water liberated by the melting ice dispersed and rearranged the moraine material. To a geographer the interest centered rather in seeing how the scenery and structure of great stretches of country were determined by the heaping up upon the plains of extensive systems of low hills—low, that is, when compared with the Alps, for some of them exceed a thousand feet in height—differing entirely from the mountains of elevation lying beyond them. These hills and fluvio-glacial plateaus represent the amount of glacial erosion and transport; they are the rubbish heaps of the mountain sculpture. Their effect on the broad geographical features of the alpine border is very clear in determining the lines of communication. The amount of weathering they have undergone, according to the different ages of the deposits, decides the character of the soil, which in turn reacts on the vegetation and appeals directly to the eye, the general aspect of the landscapes of the first glaciation dif-

fering in a marked degree from those of the last. Unfortunately, the weather was throughout unsatisfactory for photography, and the attempts made to take comprehensive views were failures, as had been expected. Some fair results were, however, obtained in detailed sections, which are of geological rather than geographical interest.

The excursionists met at Lugano on Monday, September 17, when thirty-seven members assembled, including representatives of Austria-Hungary, Germany, France, Russia, Norway, Holland, Switzerland, Italy, the United States, England, and Scotland. The weather was hopelessly wet, the one interesting result of which was to throw into the shade the distinguishing peculiarities of the Italian lakes, and reveal the essential similarity of their scenery to that of the English lakes and Scottish lochs. Professor Penck explained, and in some cases subsequently demonstrated, that the lower ends of the North Italian lakes were dammed by glacial accumulations, thus raising their level far above the rim of the rock-basins which contain their deeper water, and accounting for such peculiarities as the "recurved hook" of Lugano.

A somewhat exciting boat-trip down the rapid Ticino landed the geologists at a fine section where the river had cut deeply through its moraine bar. Here, so far as sky or soil or vegetation were concerned, one might have been in Scotland instead of Italy. The steep bowlder-clay slope, grown in part with the common coltsfoot, when ascended, led to a level moorland, the poor soil of which was covered with heather, not shrubby as in more northern latitude, but composed of long separate flower-stems with exceptionally large heads of blossom. In the distance sombre pine woods crowned the hillocks, but at a turn of the path maize and sorghum were found as common field-crops, and the similarity to northern lands disappeared.

On Monday evening the party reached Ivrea by steam tramway from Santhia, and the whole of Tuesday was occupied in seeing, as well as the mist would allow, the vast glacial amphitheater which surrounds the town, and in crossing the steep ridge of the Serra and the ferretto-covered slopes of moorland which succeed it to Biella, whence Milan was reached not long before midnight.

The morainic amphitheater is both the largest and most typical of the southern slopes of the Alps. Two ramparts of moraine material diverge nearly at right angles from the mouth of the narrow valley of the Dora Baltea, gradually diminishing in height, and these are finally united by an arc of moraines convex to the south, so that the whole completely surrounds a central plain, the two little lakes occupying the center of which overflow by the Doire, which cuts across the

southern barrier. The eastern side of the amphitheater includes the largest moraine hill of the system, so large that it by no means belies its name of the *Serra*. It is a ridge more than 12 miles long, and in its highest part more than 1300 feet above the bottom of the depression, towards which the sides slope at an angle of 20°. The accumulation is the result of several glaciations, the *moraine externe*, or early bowlder-clay, being covered with a red weathered crust of *ferretto*, the intercalation of which between the older and newer moraines is one of the proofs of the occurrence of an interglacial period.

A railway journey next morning allowed a fine forenoon to be spent in driving from Lonato to Salo, on the Garda Lake, through moraines and fluvio-glacial formations—some of them compact conglomerates. Here the successive glaciations were very clearly shown in several sections, the lower moraine of the earlier Ice Age having its pebbles much weathered; in some cases even the granites had crumbled into clay, retaining only their original form. Above this came a layer of conglomerate formed of ice-scratched pebbles stratified by running water, and on the top a fresher bowlder-clay much less weathered than that below.

Coming up the Garda Lake at night, the contrast between physical and political geography was finely shown by the uniform cliff walls and continuous water-surface broken by the long beam of the electric search-light at the Italian frontier station, which swept the lake all night for the prevention of smuggling.

On Thursday, September 20, the excursion left Riva by rail at 6·20, and had an excellent opportunity, on the journey to the Brenner line at Mori, of seeing that ice is not the only agent which is capable of producing scenery by the accumulation of detritus. The landslip-covered plateau of Loppo, with its lake formed in a hollow of the dolomitic detritus, and the still more extensive piles of landslip material about Mori, contrasted and compared in many ways with the glacial phenomena seen farther south. The Austrian Railway Company had provided, free of charge, an observation car at the end of the train, from which a good view was obtained of the deltaic wilderness through which the lateral tributaries entered the Adige, and of the extraordinary fertility of the alluvial flats, where maize and vines in alternate narrow strips covered almost all the available land. Later the porphyrite gorges marked the passage across the center of the range, and beyond the Brenner saddle carriages were provided at Matrei to allow of a more detailed examination of the terraces of the Sill valley than would be possible from the train. The vastness of this accumulation of moraine, fluvio-glacial deposit, and moraine

again, may be judged from the fact that it fills the ancient valley of the Sill, and that the modern river had to cut down through more than 300 feet of it before coming to the underlying rock, into which the river bed has now worn its way to some depth. As the road winds along the face of the steep slope of the clay gorge, it affords a view of the railway on the opposite side far below, cut in the hard rocks close to the river, while the slope above is so unstable that it remains in many places bare of vegetation, and wattled fences have been run along in zigzags to bind the clay and reduce the risk of damage to the roadway by sudden falls. In the moraine material the action of sub-aërial denudation has produced a number of "fairy chimneys," the *Erdpyramiden*, or earth-pillars, with which the name of Tyrol is usually associated in elementary text-books of geology; but they are neither so large nor so picturesque as those of the Finsterbach, the view of which so well repays the labor of the arduous climb from Botzen to the Ritten plateau.

Two nights were spent at Innsbruck, and the whole of Friday the 21st was devoted to the study of the sections along the mountain slope of the left side of the Inn. Here the interglacial deposits were seen in their most impressive form. A steep climb along a clay slope of unquestionable moraine, crowded with highly polished and striated pebbles, showed an overhanging cornice of compact breccia resting on the moraine, and itself a hardened water-bedded deposit. Mayr's great quarry in this reddish breccia is a prominent object as seen from Innsbruck, and has supplied a great part of the stone which, from its hardness and durability, causes the newer streets of that town to recall the clear-cut buildings of Aberdeen. Above Mayr's quarry comes a nearly level plateau—the top of the terrace of accumulation—1000 feet above the flat floor of the valley, and similar in its features to the terrace of the Wippthal, through which the Sill cuts its way, as seen from Schönberg. As the quarry is carried farther back the loose material above the hard breccia is cleared away in advance, and so a series of excellent sections of the upper moraine is exposed. The intercalation of this mass of breccia, several hundred feet thick, is a proof of the comparatively long duration of the interglacial period in which, according to Penck, it was formed as a talus or scree on the shores of the ancient Inn lake.

The remarkable terrace which breaks the steep slope of the mountains on both sides of the Inn valley is only found between the Oetzthal and the Zillerthal, from each of which glacial accumulations had blocked the main valley, thus giving origin to a lake which, invading the lower Wippthal also,

allowed the interglacial deposits to form on its margins, which are now represented by the top of the lateral terrace.

From Innsbruck the excursion proceeded by rail along the Inn valley into Bavaria, then by a branch line across the glacial amphitheater of the Inn, and the monotonous plain south of Munich to Deisenhofen, whence the Isar was reached on foot. The contrast of the uniform levels and low moraine hills of this northern slope, with their ranges of rather dwarfish pines in monotonous plantations, was sharp when compared with the more abrupt slopes and richer vegetation of the southern side. The true plateau character of this country appeared when, after a walk of several miles along a straight and absolutely level road, a break in the line of trees in front showed the swift Isar flowing almost at our feet, and a steep path descending the gorge to its shore. Crossing the river we reached Höllriegelskreut, and saw a succession of sections demonstrating the triple glaciation and intermediate genial periods. Next day a trip was made from Munich to the Würmsee, or Lake of Starnberg; but the weather proved so unfavorable that, for the first time on the excursion, the full programme for the day as planned by the leaders could not be carried out. It was possible, however, to visit a remarkable surface of interglacial conglomerate at Berg, which has been enclosed and placed under cover by the German and Austrian Alpine Club, a body which has rendered inestimable services to the scientific visitor, as well as the tourist and climber, along the whole line of the Eastern Alps. This surface is so strongly glaciated that the rock is polished as if by a lapidary, and the internal structure of every constituent pebble is clearly seen. The characteristic striæ are there, showing how the glacier, long since shrunk back to the obscurity of the central Alpine ridge, had advanced over the hardened mass of cemented pebbles sorted out by water from an earlier moraine, and cut by its intense erosive power through pebbles and matrix alike. The Würmsee is deeper below the general level of the plain than the surrounding hills are high above the surface, and it is entirely surrounded by the interglacial deposits known as *Deckenschotter*, in which it seems probable that the whole basin was eroded beneath the pressure of the last great ice sheet.

In concluding this short account of a delightful and memorable excursion, it may be of advantage to define the nomenclature and summarize the general theoretical conclusions arrived at by Drs. Penck, Brückner, and Du Pasquier.

Glacial deposits, so far as they occur in the Alps, are divided into two classes—the *glacial*, or moraines properly so called; and the *fluvio-glacial*, or alluvia formed by the action of running water on moraines. The latter are usually clearly strati-

fied, but contain many pebbles marked by glacial striæ. Fluvio-glacial deposits are always being formed on the outer slopes of moraines, forming a gentle slope leading from the edge of the morainic amphitheater to the plain of the enclosed depression. A complex of glacial and fluvio-glacial deposits of contemporaneous origin corresponds to each phase of the cessation of glaciation. Thus in a single glacial series there may be a succession of complexes, one partially superimposed on another, and each corresponding to a definite stage of retreat or advance of the ice. The fluvio-glacial deposits in a single glaciation are spoken of as inter-stadiary.

Under the deposits of relatively recent glacial accumulation which are characterized by trifling superficial alteration due to weathering, two other glacial series are found distinguished from each other and from the most recent series by highly weathered layers or by evidence of great erosion, showing the existence of a long sub-aërial period between each epoch of glaciation. These periods are termed interglacial in distinction to the brief interstadiary periods which occur in the course of a single glaciation. Amongst the interglacial deposits of the neighborhood of the Alps, at least on the north of the chain, *loess* must be included. *Lehm* is a product of alteration of loess, mainly distinguished by the absence of carbonate of lime.

The more ancient moraines are often weathered externally into a brick-red crust, termed *ferretto* by the Italian geologists. The moraines so coated always occupy the outer side of morainic amphitheaters, and are therefore called *external moraines* in distinction to the more *internal moraines*, which form the inner slopes and in part rest upon the more ancient. This is not a mere case of superposition, but of actual enclosure, the external moraine extending around as well as partially under the internal. The alluvia of the most ancient glaciation are termed *plateau alluvia* (Deckenschotter), those of the intermediate glaciation *high-terrace alluvia* (Hochterrassenschotter), and those of the most recent stage *low-terrace alluvia* (Niederterrassenschotter).

I cannot conclude without an expression of gratitude to Professor Penck, for his great kindness and tireless patience in not only showing, but making sure that every member of the excursion saw and understood, the various features which he explained.

ART. XIII.—*Distribution of the Echinoderms of Northeastern America;** by A. E. VERRILL. (Brief Contributions to Zoology from the Museum of Yale College, No. LVIII.)

ABOUT 200 species of Echinoderms are now known from the Atlantic Ocean, adjacent to the North American coast, north of Cape Hatteras. Of these, over 100 species have been discovered in recent years, since the deep sea dredgings were undertaken. The "Challenger," 1873; the "Blake," 1880; the "Fishhawk," 1880–1882; and the "Albatross," 1883–1887, each brought to light many new forms. Those dredged by the "Challenger" were, however, not described until 1889. Those collected by the two steamers last named, as well as several derived from previous explorations, were mostly described by me, from 1878 to 1885. Many of these necessarily brief descriptions appeared in this Journal, from time to time, in this series of "Brief Contributions to Zoology."† It seems desirable, therefore, to bring together here all the species, with a brief review of their distribution, as known at present. Of the 200 species now recognized, about 137 may be classed as deep-water species, as they rarely if ever occur in less than 50 fathoms. About 116 species are found in depths greater than 500 fathoms. Many of these have a wide range in bathymetrical distribution, some of them ranging from less than 100, to more than 1000 fathoms. The same is true of some of the shallow water species. About 58 species have been found to occur only at depths greater than 500 fathoms; these may be classed as true abyssal species. Many of our species also have a wide geographical range. A considerable number occur on the eastern side of the Atlantic and in the Arctic Ocean. Several extend southward to the West Indies, and some even to the Indian and Pacific Oceans.

More complete details in regard to the distribution will be given in connection with the general lists of each class. The general distribution in depth may be illustrated by the following table:—

* Abstract of a paper read before the National Academy of Science, Dec. 31, 1894.

† Especially in Nos. 38, 39, 42, 49, 50, 51, 55, 56, 57.

Other species were described by me in the Proc. U. S. Nat. Museum, vol. ii, p. 165, 1879; vol. viii, p. 423, 1885; and in vol. xvii, pp. 245–297, 1894.

Many were figured and described, in "Results of the Explorations made by the steamer Albatross, in 1883," in the 11th Annual Report of the Commissioner of Fish and Fisheries, 1885.

In this article the localities indicated by station numbers and by latitude and longitude, unless otherwise stated, are those of the United States Fish Commission.

Bathymetrical Distribution of N. E. American Echinoderms.

Fathoms.	Aster.	Ophiur.	Crin.	Echin.	Holoth.	Total.
0–50	26	17	1	5	25	74
50–100	37	20	2	12	12	83
100–500	35	30	2	17	9	93
500–1000	24	26	2	10	11	73
1000–2000	22	26	1	12	13	74
2000–2600	7	7	2	0	5	21

It will be seen from the above table that the species of Echinoderms are more numerous between 100 and 500 fathoms than in any other zone of depth. It is also in this zone that many species occur in the greatest abundance of individuals. This is largely due to the fact that off much of our coast, a profuse fauna is sustained at those depths by the direct influence of the Gulf Stream, as shown in several of my former articles.

A brief statement of some of the results and conclusions, arrived at from the study of this group, may be given here, leaving a more detailed discussion of the subject for another occasion.

1. The abyssal genera and families are mostly very widely diffused over the three great ocean basins.

2. The species belonging to abyssal genera are usually restricted in range to particular regions or to a single ocean.

3. Those genera and species having the greatest bathymetrical range are also generally the most widely distributed geographically. Some of these species range from very shallow water to 1000 fathoms or more, and may extend geographically into all the great oceans.

4. Some of those species belonging to the intermediate depths (100 to 500 fath.), known as the "continental zone," often have a very wide geographical range. Many of them extend to European waters, and some even to the Pacific.

5. Many of the most peculiar and remarkable new genera belong to the continental zone, or even between 50 and 200 fathoms.

6. Many peculiar and conspicuous genera and several remarkable families are nearly or quite confined to the abyssal zone.

7. Abyssal genera are often endowed with special structures adapted to the peculiar physical and biological conditions in which they live, especially to the food upon which they feed and to the soft mud or ooze in which most of them live more or less buried.

8. The abyssal species in many cases appear to be capable only of very slow dispersion, as compared with shallow water species. This is, at least in many cases, due to the fact that

many of them do not have free-swimming larvæ, but bring forth well developed creeping young; as, for example, the Pterasteridæ, Solasteridæ, Echinasteridæ, Astrophytonidæ, etc.

In other cases the eggs are so large as to indicate that the larvæ (though unknown) are unlike those of shallow water species and not free-swimming.

9. It is, therefore, probable that many of the strictly abyssal species do not have the benefit of the transporting agency of ocean currents, which so rapidly transport the free larvæ of most shallow-water species. If that be the case, they can only extend their range by the extremely slow process of creeping by means of their ambulacral feet, which, on the soft ooze of the sea bottom, must be a very slow process.

10. We must, therefore, conclude that the widely diffused abyssal genera, many of which now occupy all the great ocean basins, and in many cases range from the Arctic to the Antarctic Oceans, are of very great antiquity, and that there has been ample time, since they occupied the deep sea, for the minor differences characteristic of species to originate in different geographical regions, as a result of casual variations that have been conserved by isolation, perhaps aided in some cases by "natural selection."

11. In the majority of cases, however, there is no evident utility in the characters that separate one abyssal species from another of the same genus, for the differences are generally slight modifications of form and color; arrangement, shape and size of the spines, granulations, pedicellariæ, etc. Such differences can hardly be of protective value in the darkness and quietness of the depths in which they live.

*Systematic List of the Starfishes, with their Bathymetrical and Geographical Distribution, expressed in a condensed form.**

ASTERIOIDEA

Family ARCHASTERIDÆ (Viguier, 1878) emended, Sladen.

BENTHOPECTEN SPINOSUS Verrill.

Benthopecten spinosus Verrill, this Journal, vol. xxviii, p. 218, 1884; Explorations made by the Albatross in 1883, in Annual Report, U. S. Comm. of Fish and Fisheries, pp. 519 [17], 543 [41], 1885; Proc. Nat. Mus., vol. xvii, p. 245, 1894.

Pararchaster semisquamatus var. *occidentalis* Sladen, Voyage of the Challenger, vol. xxx, p. 10, 1889.

Pararchaster armatus Sladen, op. cit., p. 19, pl. 1, figs. 5, 6; pl. 4, figs. 5, 6, 1889.

* In this list, as a matter of convenience, I have followed pretty nearly the arrangement and nomenclature adopted by Mr. Sladen in his classical work on the Starfishes collected by the Challenger. (Report on Scientific Results, Zoology, vol. xxx, with a vol. of plates).

In doing this I do not necessarily approve of all the changes of names made by him. In several cases I decline to follow him and others in the resurrection of the ante-Linnæan names given by Linck. To do this systematically would produce endless confusion.

Bathymetrical range, 721 to 2021 fathoms. Most common in 1200 to 1600 fathoms. It was taken at 60 stations, between N. lat. 42° 47′ and 35° 10′, by the U. S. Fish Commission. Off the coast of Portugal (t. Sladen).

The genus *Pararchaster* Sladen (1889) is synonymous with *Benthopecten* (1884). This is a strictly deep-sea genus, none of the species occurring in less than 400 fathoms. It is found in all the oceans. The following additional species were described by Mr. Sladen:—

B. spinosissimus (Sl.) V., Atlantic	425	fath.
B. simplex (Perrier) V., Caribbean	1323	"
B. antarcticus (Sl.) V., Southern Ocean	1675	"
B. pedicifer (Sl.) V., " "	1600–1900	"
B. semisquamatus (Sl.) V., Pacific	565–1875	"

All the above species are closely related. Mr. Sladen also described a single young specimen, taken off Delaware Bay by the Challenger, as a variety (*occidentalis*) of *B. semisquamatus*. The type of the latter was from off Japan.

This supposed variety appears to me to agree in all respects with many young specimens of our *B. spinosus*, judging from Mr. Sladen's detailed description. The two species are evidently very closely allied.

PONTASTER HEBITUS Sladen.

Pontaster hebitus Sladen, Voyage of the Challenger, vol. xxx, p. 33, pl. 8, figs. 1, 2; pl. 12, figs. 1, 2, 1889; Verrill, Proc. U. S. Nat. Mus., vol. xvii, p. 247, 1894.

Archaster tenuispinus Verrill, Proc. U. S. Nat. Mus., vol. ii, p. 203, 1879; Rep. Com'r of Fish and Fisheries, vol. xi, for 1883, p. 543, pl. 13, fig. 38, 1885 (perhaps not of Düben and Koren).

B. range, 85 to 250 fath. This species is known only from the Banks off Nova Scotia and Newfoundland. It is very closely allied to *P. tenuispinus* of northern Europe, if not identical.

Mr. Sladen records twelve species and several varieties of *Pontaster*, not including *P. sepitus*. Seven species occur in the Atlantic. Others are found in the Indo-Pacific and Southern Oceans, mostly at great depths. Mr. Perrier has also described several additional forms that appear to belong to the same genus. Three of these are from the West Indian seas.

PONTASTER FORCIPATUS Sladen.

Pontaster forcipatus Sladen, Voyage of the Challenger, xxx, p. 43, pl. 8, figs. 3, 4; pl. 12, figs. 3, 4, 1889; Verrill, Proc. Nat. Mus., vol. xvii, p. 247.

B. range, 828 to 1396 fath. 1240 to 1700 fath. (Sladen). Taken at 45 stations, between N. lat. 41° 28′ and 36° 34′.

Mr. Sladen (op. cit., p. 47) has described a variety (*echinata*) of this species, taken off Marion Island, S. lat. 46° 46′, in 1375 fathoms.

Allied species are found in all the great oceans.

PONTASTER SEPITUS Verrill.

Archaster sepitus Verrill, this Journal, vol. xxix, p. 151, Feb., 1885; Expl. by the Albatross in 1883, pp. 519, 543, 1885.
Pontaster sepitus Verrill, Proc. Nat. Mus., vol. xvii, p. 247, 1894.

B. range, 368 to 858 fath.
Taken at several stations between N. lat. 41° 53′ and 39° 40′.

DYTASTER GRANDIS Verrill.

Archaster grandis Verrill, this Journal, vol. xxviii, p. 218, 1884.
Dytaster madreporifer Sladen, op. cit., p. 70, pl. 3, figs. 3, 4; pl. 32, figs. 5, 6, 1889.
Dytaster grandis Verrill, Proc. U. S. Nat. Mus., vol. xvii, p. 248, 1894.

B. range, 475 to 2620 fath. Most common between 1200 and 1600 fathoms. Taken at 36 stations between N. lat. 41° 13′ and 36° 34′.

The genus *Dytaster* Sladen is found in all the great oceans. Mr. Sladen described seven species, none of them from less than 800 fathoms.

D. exilis var. *carinata* Sl., op. cit., p. 69, was taken off Maryland, in 1700 fathoms. The typical *D. exilis* was from off Valparaiso, in 1375 fath. I have not been able to satisfy myself that the var. *carinata* Sl. is distinct from the young of *D. grandis*.

PLUTONASTER AGASSIZII Verrill.

Archaster Agassizii Verrill, this Journal, vol. xx, p. 403, 1880.
Plutonaster rigidus Sladen, op. cit., p. 91, pl. 14, figs. 3, 4; pl. 15, figs. 3, 4, 1889; also var. *semiarmata*, op. cit., p. 94.
Plutonaster bifrons (part) Sladen, op cit., p. 88, 1889 (very young example).
Plutonaster Agassizii Verrill, Proc. Nat. Mus., vol. xvii, p. 248, 1894.

B. range, 182 to 1700 fath. Most common in 300 to 1200 fathoms. Taken at 103 stations between N. lat. 41° 53′ and 35° 45′ 23″.

Very closely related to *Pontaster bifrons* Sl. from off the European coasts, and to *Pontaster intermedius* (Perrier sp.), of the West Indian region.

Mr. Sladen recorded eight species of this genus: one from the Mediterranean; one from the South Pacific; all the others from the Atlantic. Most of the species inhabit only great depths.

PSEUDARCHASTER INTERMEDIUS Sladen.

Pseudarchaster intermedius Sladen, Voyage of the Challenger, vol. xxx, p. 115, pl. 19, figs. 3, 4; pl. 42, figs. 5, 6, 1889; Verrill, Proc. Nat. Mus., vol. xvii, p. 249, 1894.
Archaster Parelii Verrill, this Journal, vol. vii, p. 500, 1874 (not Düben and Koren); vol. xxiii, p. 140, 1882; Rep. U. S. Com'r Fish and Fisheries, vol. xi, p. 543, pl. 13, fig. 37, 1885 (var. with narrow rays).

B. range, 85 to 1608 fath. Most common between 150 and 500 fath. Taken at 33 stations between N. lat. 44° 26′ and 37° 59′ 30″.

This species is very closely allied to *P. discus* Sladen, from off the west coast of S. America in 147 fath., and to *P. tessellatus* Sl., from the Cape of Good Hope.

Variety, *insignis* nov.

A few specimens, much larger than usual and with coarser granules, represent a marked variety or perhaps a distinct species. For the present it may be best to consider it a variety.

Radii, 75^{mm} and 23^{mm}. Upper surface and marginal plates granulated nearly as in the typical form, except that the granules are somewhat larger. Actinal plates covered with unequal, coarse, irregular, angular, fusiform granules, some of those on the middle of each plate longer and larger, spiniform. Lower marginal plates with a median row of small, appressed, fusiform spines much larger than the granules. Adambulacral spines longer and larger than in the type-form, those on the ventral side of the plates, 12–16; the largest, thick and blunt, or clavate. Jaw-spines thick, blunt, angular, longer and more prominent than in the type, those on the actinal surface in two regular rows of about 8 each.

B. range, 100 to 1356 fath. Nova Scotia to N. lat. 40° 09′ 30″.

PSEUDARCHASTER CONCINNUS Verrill.
Proc. U. S. Nat. Mus., vol. xvii, p. 250, 1894.

B. range, 1188 to 1791 fath. In one instance recorded as from 123 fathoms, but probably erroneously. Taken at 3 stations between N. lat. 41° 28′ 30″ and 41° 07′.

Family PORCELLANASTERIDÆ Sladen.

CTENODISCUS CRISPATUS Dub. and Koren.
Asterias crispatus Retzius, Dissert. Asteriarum, p. 17, 1805.
Ctenodiscus polaris Müll. and Trosch., Syst., p. 76, pl. 5, fig. 5, 1842.
Ctenodiscus crispatus Duben and Kor., K. Vet. Akad. Handl., p. 253, 1844; Stimpson, Invert. G. Manan, p. 15, 1853; Lütken, Grönl. Echinod., p. 45, 1857; Verrill, Proc. Bost. Soc. Nat. Hist., vol. x, p. 345, 1866.
Ctenodiscus corniculatus Perrier, Stell. du Mus., p. 380, 1875; Duncan and Sladen, Echinod. Arctic Sea, p. 49, pl. 3, figs. 17–20, 1881; Sladen, Voy. Chall., p. 171, 1889.*

B. range, 5 to 632 fath. Most abundant from 50 to 150 fath. Taken at numerous stations in Massachusetts Bay, Gulf of Maine, Bay of Fundy, etc. It extends to Greenland, Spitzbergen, and Northern Europe. Circumpolar. Allied species occur in the South Atlantic and South Pacific.

* This is an instance in which certain writers have resurrected Linck's antebinomial names to displace those given under the Linnæan system. In this I cannot concur.

PORCELLANASTER CÆRULEUS Thoms.

W. Thomson, Voy. Challenger, Atlantic, vol. i, p. 378, figs. 97, 98, 1877; Sladen, Voy. Chall., vol. xxx, p. 134. pl. 20 figs. 1 to 7, 1889; Verrill, Expl. by the Albatross in 1883, p. 543, pl. 14, figs. 40, 41, 1885.

B. range, 662 to 1917 fath. Most common from 900 to 1500 fath. Taken at 42 stations between N. lat. 41° 28′ and 37° 50′. Found also off the European coasts.

This genus is found at great depths in all the oceans. About 10 species are known.

Family ASTROPECTINIDÆ (Gray, 1840) emended.

ASTROPECTEN AMERICANUS Verrill.

Archaster Americanus Verrill. this Journal, vol. xx, p. 402, 1880.
Astropecten Americanus Verrill, Proc. Nat. Mus., vol. xvii, p. 255, 1894.

B. range, 43 to 296 fath. Most common from 63 to 150 fath. Taken by the U. S. Fish Comm. at 72 stations, from N. lat. 40° 23′ to 35° 38′. Allied species occur in all seas. *A. mesacutus* Sl., from the East Atlantic, seems to be the nearest related.

ASTROPECTEN VESTITUS Lütken.

Asterias vestita Say, Journ. Philad. Acad., vol. v, p. 143, 1825.

B. range, shallow water. Cape May (Say.). It is not uncommon farther south.

ASTROPECTEN ARTICULATUS Müll. and Trosch.

Asterias articulatus Say, Journ. Acad. Nat. Sci., Philad., vol. v, p. 141, 1825.
Astropecten articulatus Müll. and Trosch., Syst. Aster., p 72, 1842; A. Agassiz, North American Starfishes, p. 114, pl. 19, figs. 1–8, 1877.

B. range, 4 to 43 fath. Taken at several stations off Cape Hatteras, and as far north as 35° 42′. Common farther south, in shallow water. West Indies.

LEPTOPTYCHASTER ARCTICUS Sladen.

Astropecten arcticus M. Sars, Reise Lofoden og Finmarken, Nyt. Mag. Nat., vol. vi, p. 161, 1851.
Archaster arcticus Verrill, this Journal, vol. xvi, p. 214, 1878.
Leptoptychaster arcticus, var. *elongatus*, Sladen, op. cit., p. 189.
Leptoptychaster arcticus Sladen, op. cit., p. 189; Verrill, Proc. Nat. Mus., vol. xvii, p. 255, 1894.

B. range, 50 to 965 fath. (1350 fath., Sladen). Most common in 85 to 200 fathoms; rare at greater depths. Taken at 23 stations, from N. lat. 45° 14′ to 38° 29′. It always occurred in small numbers. It is also found off the northern coasts of Europe. Two closely allied species are found in the Antarctic Ocean.

PSILASTER FLORÆ Verrill.

Archaster Floræ Verrill, this Journal, vol. xvi, p. 372, 1878; Expl. by the Albatross, in Ann. Rep. U. S. Com'r Fish and Fisheries, vol. xi, p. 542, pl. 13, fig. 36, 1885.
Psilaster Floræ Verrill, Proc. Nat. Mus., vol. xvii, p. 255, 1894.

B. range, 53 to 452 fath.; in one instance in 984 fath. (perhaps an error). Most common in 150 to 350 fath. Taken by the U. S. Fish Comm. at 70 stations between N. lat. 44° 47′ and 38° 27′. It has also been sent by the Gloucester fishermen, from several localities on the various Banks off Nova Scotia, in 60 to 230 fath.

This is closely allied to *P. Andromeda* of Northern Europe (40 to 690 fath.), and may eventually prove to be identical. Several allied species are known from the East Atlantic, Indian, and Pacific Oceans.

BATHYBIASTER ROBUSTUS Verrill.

Archaster robustus Verrill, this Journal, xxix, p. 383, 1885; Expl. by the Albatross in 1883. pp. 519, 541, 1885.

Phoxaster pumilus Sladen, op. cit., p. 236, pl. 15, figs. 3–6; pl. 40, figs. 7–11, 1889 (Young).

Bathybiaster robustus Verrill, Proc. Nat. Mus., vol. xvii, p. 256, 1894.

B. range, 705 to 1467 fath.; 1240 to 1700 (Sladen). Taken at 33 stations between N. lat. 41° 28′ and 35° 10′.

This is closely allied to *B. pallidus* from off the Scandinavian coast. An allied species occurs in the South Pacific and Antarctic Oceans, in 75 to 245 fath.

LUIDIA CLATHRATA (Say).

Asterias clathrata Say, Journ. Acad. Nat. Sci., Philad., vol. v, p. 142, 1825.

Luidia clathrata Lutken, Vidensk. Meddel., p. 37, 1859; A. Agassiz, North American Starfishes, p. 117, pl. 20, 1877; Verrill, this Journ., vol. iii, p. 438, 1872.

B. range, 1 to 48 fath. Most common in less than 20 fath. Taken at 18 stations, from N. lat. 37° 31′ to 35° 12′. Common in shallow water southward to Florida, West Indies, and Rio Janeiro, Brazil. Rare north of Cape Hatteras.

Allied species occur in all tropical seas.

LUIDIA ELEGANS Perrier.

Luidia elegans Perrier, Arch. Zool. Expér., p. 256, 1876; Verrill, this Journal, vol. xx, p. 403, 1880; Expl. by the Albatross, in Ann. Rep. U. S. Fish Comm., vol. xi, p. 543, pl. 13, figs. 39, 39ª, 1885.

B. range, 53 to 146 fath. Most common from 60 to 120 fath. Taken at 34 stations between N. lat. 40° 16′ and 35° 10′ 40″. Seldom obtained entire. Appears to extend to the West Indies.

Family GONIASTERIDÆ or PENTAGONASTERIDÆ.

PENTAGONASTER EXIMIUS Verrill.

Proc. Nat. Mus., vol. xvii, p. 264, 1894.

B. range, 80 to 122 fath., rare. Taken at two stations, N. lat. 44° 27′ 30″ and 42° 25′ 40″.

Closely allied to the following species.

PENTAGONASTER GRANULARIS Perrier.

Asterias granularis Retzius, K. Vet. Akad. Nya. Handl., vol. iv, p. 238, 1783.
Astrogonium granulare Müller and Trosch., Syst., p. 57, 1842; Verrill, Expl. by the Albatross in 1883, p. 542, pl. 18, figs. 48, 48ª, 1885.
Goniaster granularis Lütken, Vidensk. Medd. nat Foren., p. 146, 1865.
Pentagonaster granularis Perrier, Revis. Stell. du Mus., p. 224, 1876; Sladen, Voy. Challenger, vol. xxx, p. 268, 1889.

B. range, 72 to 471 fath. Rarely taken below 150 fathoms. Taken at several stations between N. lat. 44° 28′ 30″ and 41° 47′. Also taken by the Gloucester fishermen on the Banks off Nova Scotia. Occurs off the coasts of Norway and Great Britain.

PENTAGONASTER SIMPLEX, sp. nov.

B. range, 640 fath. Off Martha's Vineyard.

Greater radius, 20^{mm}; lesser radius, 13^{mm}; thickness at margin, 45^{mm}. Form pentagonal, with the sides slightly incurved; rays short-triangular, terminated by a somewhat prominent, rounded apical plate, situated on the upper side. Usually twelve superior and fourteen inferior marginal plates; these are uniformly covered with rather fine, crowded, angular granules, except on the middle of each plate, where there is a smooth, rounded area above and below. Abactinal plates very regular in form and arrangement; those of the radial areas are hexagonal, with the median row distinct and bordered by about three parallel rows on each side. Those of the triangular interradial areas are rhombic, somewhat smaller and less regular; all the plates are covered with numerous small, crowded, angular granules, often thirty to forty on the larger plates. Actinal plates mostly rhombic, flat, regularly arranged, and covered with fine, rounded granules which are not closely crowded. Adambulacral spines decidedly longer and larger than those adjacent. Each adambulacral plate bears a single marginal row of three or four somewhat elongated, blunt or clavate spines, and outside of these a somewhat stellate group of seven to nine shorter, thicker, blunt spinules, one of which usually occupies the center of the group. Jaw-spines numerous, short, thick, angular, similar to the larger adambulacral spines.

A single specimen (No. 13,363) was taken at station 1124.

PENTAGONASTER PLANUS, sp. nov.

B. range, 156 fath. N. lat. 39° 53′, off Martha's Vineyard.

Greater radius, 50^{mm}; lesser radius, 35^{mm}; thickness at margin, 8^{mm}. Form pentagonal, with the sides slightly incurved; rays very short, triangular, and obtuse, with the tip turned up and terminated by a small, conical plate. Marginal plates large, median ones nearly square, usually fourteen in the dorsal

series and sixteen in the ventral series, all uniformly covered with rather coarse, rounded granules, standing a little apart, the margins of the plates with a regular row of granules of about the same size. Abactinal plates flat, mostly rather large, rounded or hexagonal, with some small, rounded ones interspersed; all are uniformly covered with rather coarse, spaced granules, like those of the marginal plates, so that the whole of the upper surface has a remarkably uniform granular coating. The larger plates often bear fifty to seventy granules; the small intermediate plates frequently carry but nine to twelve. Actinal plates large, rhombic, uniformly covered with coarse, angular granules, distinctly larger than those of the marginal plates. Adambulacral plates numerous and crowded, similar to the actinal plates, but slightly larger and longer, the length increasing somewhat toward the ends of the rays. Each plate usually bears three or four marginal spines in a simple row; outside of these there are usually nine to twelve thicker, obtuse, angular spines, forming four irregular, longitudinal rows, the outer ones smallest. Jaws covered with numerous blunt, angular spines, similar to the actinal spines, but larger. One specimen (No. 13,362) was taken at station 1098.

ODONTASTER HISPIDUS Verrill.
Odontaster hispidus Verrill, this Journal, vol. xx, p. 402, 1880; Proc. Nat. Mus., vol. xvii, p. 263, 1894.

B. range, 43 to 1230 fath. Taken at many stations between N. lat. 44′ 28° 30″ and 39° 53′.

No very closely allied species is known.

The genus *Gnathaster* (Sladen, 1889) appears to be identical with this. Among the recorded species are the following:

Odontaster pilulatus (*Gnathaster* Sl.) Magellan St.
O. elongatus (*Gnathaster* Sl.) Southern Ocean.
O. singularis (*Astrogonium* M. and Tr.) W. S. America.
O. miliaris (*Astrogonium* Gray) N. Zealand.
O. paxillosum (*Astrogonium* Gray) Australia.
O. dilatatus (*Pentagonaster* Per.) N. Zealand.
O. meridionalis (*Astrogonium* Smith) Southern Ocean.
O. Grayi (*Calliderma* Bell) Magellan Str.

ISASTER BAIRDII Verrill.
Archaster Bairdii Verrill, this Journal, vol. xxiii, p. 139, 1882.
Isaster Bairdii Verrill, Proc. Nat. Mus., vol. xvii, p. 258, 1894.

B. range, 351 to 721 fath. Taken at 6 stations between N. lat. 42° 55′ 30″ and 39° 47′ 07″.

No other species of this genus is known.

PARAGONASTER FORMOSUS Verrill.

Archaster formosus Verrill, this Journal, vol. xxviii, p. 383, 1884; Expl. by the Albatross in 1883, pp. 519, 543.

? *Paragonaster cylindratus* Sladen, op. cit., p. 314, pl. 51, figs. 3, 4; pl. 53, figs. 3, 4, 1889.

Paragonaster formosus Verrill, Proc. Nat. Mus., vol. xvii, p. 257, 1894.

B. range 1396 to 2021 fath. Taken at 15 stations between N. lat. 41° 07′ and 37°.

The type of *P. cylindratus* Sl. was from south of Cape Verde Islands, in 1850 fath.

A West Indian species (*P. subtilis* = *Goniopecten subtilis* Perrier), appears to be closely allied to ours. It was taken in 955 fathoms by the "Blake" Exp.

HIPPASTERIA PHRYGIANA Ag.

Asterias phrygiana Parelius, K. Norske Vid. Selskabs Skrifter, vol. iv, p. 425, pl. 14, fig. 2, 1770; Gmelin, Linné, p. 3163, 1788.

Asterias equestris Pennant, Brit. Zool., vol. iv, p. 130, 1776; Lamarck, Anim. sans vert., vol. iii, p. 242, 1815.

Hippasteria plana Gray, Ann. and Mag., vol. vi, p. 279, 1841; Synopsis Starf. Brit. Mus., p. 9; Perrier, Arch. de Zool., Exper. vol. v, p. 86, 1876; Sladen, Voy. Challenger, vol. xxx, p. 341.

Goniaster equestris Forbes, British Starfishes, p. 125, fig., 1841.

Astrogonium phrygianum Müll. and Trosch, Syst. Asteriden, p. 52, 1842; Lutken, Vidensk. Meddel., pp. 70, 105, 1857; Sars Norges Echinod., p. 44.

Goniaster phrygianus Norman, Ann. and Mag. Nat. Hist., vol. xv, p. 123, 1865; Verrill, Proc. Boston Soc. Nat. Hist., vol. x, p. 356, 1866.

Hippasteria phrygiana Agassiz, Sea Side Studies, p. 113; Verrill, Check List., p. 14, 1879; Expl. by the Albatross, in Ann. Rep. U. S. Fish Comm., vol. xi, p. 542, pl. 17, fig. 47, 1885.

B. range, 20 to 224 fath.; in one instance, off George's Bank, in 471 fath. Most common from 50 to 150 fath. Newfoundland to Cape Cod, off Chatham Light. Taken at numerous stations in Massachusetts Bay, off Cape Ann, Gulf of Maine, Bay of Fundy, and off Nova Scotia, on hard bottoms. It occurs also on the European coasts and in the Arctic Ocean.

No other species of the genus is known.*

Family GYMNASTERIDÆ.

PORANIA (CHONDRASTER) GRANDIS Verrill.

This Journal, vol. xvi, p. 371, 1878; Expl. by the Albatross in 1883, in Ann. Rep. Fish Comm., vol. xi, p. 542 (*pars.*), pl. 15, fig. 44, pl. 16, fig. 44ª, 1885 (not figs. 45, 45ª).

B. range, 220 to 538 fath. East of George's Bank and off Martha's Vineyard, N. lat. 39° 53′ 30″.

This large species is not a typical *Porania*. In several of my former articles it was not distinguished from the following

* Perrier, Sladen, and others have resurrected one of Linck's ante-binomial names (*planus*) for this species. This proceeding appears to be entirely unwarranted and unnecessary.

species, which is similar in size and general appearance. The present form has a thinner margin with the plates poorly developed. The marginal spines are more or less abortive. The long, slender dorsal papulæ are confined to two petaloid bands on each ray, leaving the median area bare. There are two adambulacral spines on the inner edge of each plate, side by side, and an outer transverse series of two or three. The integument is firm, thick, and glabrous, and when dried it shows numerous microscopic spicules on the surface. The radial grooves are conspicuous and numerous; one runs from between all the adambulacral plates and marginal plates. The rudimentary abactinal and actinal plates are much less developed than in the next species.

The above characters warrant the establishment of a new subgenus, or perhaps a genus, for this species. I propose to name it *Chondraster*.

PORANIA INSIGNIS, sp. nov.

Porania grandis (pars) Verrill Explorations made by the Albatross in 1883, p. 542, pl. 15, figs. 45, 45ª, 1885.

B. range, 65 to 373 fath. Most common in 100 to 250 fath. Chiefly in the warm area. Taken at numerous stations, from N. lat. 41° 28′ 30″ to 36° 38′ 30″. It has, also, been taken several times by the Gloucester fishermen, on the Banks.

A large pentagonal species with convex disk and short rays. Radii of an average specimen 70^{mm} and 34^{mm}. Dorsal surface smooth, with a tough, leathery integument, without visible plates or spines, except a cluster of small spinules around the "anal" pore. Papulæ conspicuous, elongated; they are most abundant along the sides of the rays, but do not form very definite bands, though the median line of the rays is mostly bare; a single or double row of papulæ extends along the margins, between the upper and lower marginal plates, which are somewhat prominent, but covered by thick cuticle. The lower plates carry a row of three or four sharp, conical, skin-covered spinules, which form the sharp edge of the disk; distally the number decreases to two, and finally to one. Each adambulacral plate bears a transverse row of three or two stout, short, divergent spines, in irregular alternation; they are somewhat webbed at base; the outer one is stoutest and often gouge-shaped or even double at the blunt tip. Each jaw bears two oral, partly webbed, skin-covered, short spines, and two or three on each side. The actinal radial furrows are strongly marked; they run from between all the marginal plates, but only between alternate adambulacral plates.

Young specimens of this species, when 15 to 20^{mm} in diameter, have more or less numerous, small, scattered, simple spines, both on the dorsal and ventral plates; these plates are dis-

tinctly visible, beneath the cuticle, when dried, and the upper marginal plates are relatively larger than in the adult. The papulæ are few and scattered. In this stage, it agrees in all respects with the genus *Marginaster* Perrier and *Lasiaster* Sladen, both of which are probably the young of *Porania* or *Poraniomorpha*.

Four allied species of this genus are known from the Southern Ocean; of these *P. glabra* Sl., from off Kerguelen I., in 30 to 127 fath., seems nearest to our species; *P. pulvillus* (Müll.) Norm., of northern Europe, is also allied to this.

PORANIOMORPHA SPINULOSA Verrill.

Porania spinulosa Verrill, Proc. U. S. Nat. Mus., vol. 2, p. 202. 1877.

Poraniomorpha spinulosa Verrill, Expl. by the Albatross, p. 542, 1885.

B. range, 80 to 640 fath. Rare below 400 fath. Most common in 150 to 250 fath. In one instance, off Cape Hatteras, taken in 48 fath. Off Cape Cod in 80 and 118 fath. Taken at 42 stations from 41° 80′ 30″ to 35° 12′ 30″, mostly in the warm area.

Var. *rudis:* A variety of this species has small divergent groups of longer and somewhat enlarged spinules on more or less of the actinal interradial plates, while the rest of the plates have the normal small spinules.

Var. *inermis:* This variety lacks the marginal spines on the infero-marginal plates, except near the ends of the rays.

There is considerable variation, also, in the number of spines on the jaw-plates.

A very large specimen, with the radii 80^{mm} and 46^{mm}, taken in 90 fathoms, off Martha's Vineyard, has thick, tumid margins, with the infero-marginal plates forced downward to the under side; many of these plates along the disk are destitute of marginal spines, or have them in a more or less aborted form; toward the tips of the rays the marginal spines become normal, but stouter than in smaller specimens.

This is closely allied to *P. rosea* Duben and Koren, of northern Europe.

PORANIOMORPHA BOREALIS Verrill.

Asterina borealis Verrill, this Journal, vol. xvi, p. 213, 1878; Verrill, Expl. made by the Albatross in 1883, in Ann. Report U. S. Fish Comm., vol. xi, pl. 18, figs. 46, 46^a, 1885.

Porania borealis Verrill, Check List, 1879; Ann. Report U. S. Com'r. of Fish and Fisheries, for 1882, vol. x, p. 659, 1884.

B. range, 64 to 225 fath., rare. Belongs to the cold area. Taken at 4 stations, from 44° 26′ to 39° 49′ 30″. Also in the Gulf of Maine, in 110 fathoms, 1874. Fishing Banks, N. lat. 45° 25′, W. long. 57° 10′, in 170 fathoms.

The specimen from the Banks is much larger than any of the others. Radii 35^{mm} and 23^{mm}. The dorsal papular pores

are very numerous and conspicuous over most of the dorsal surface, in large clusters. The ventral plates are nearly uniformly covered with slender needle-shaped spinules of nearly uniform size, no groups of larger spinules being present on them.

The spinules, above and below, as well as the adambulacral spines, are decidedly longer and more slender than in *P. spinulosa*. The upper marginal plates are conspicuous, swollen, elongated vertically, but have no special spines.

A row of papulæ, between the upper and lower plates.

RHEGASTER ABYSSICOLA, sp. nov.

B. range, 2045 fathoms, N. lat. 37°, W. long. 71° 54′.

Greater radius, 35^{mm}; lesser 14^{mm}; elevation at center, 17^{mm}. Form five-rayed, stellate, with the disk flat beneath, tumid above, and indented by a distinct groove at the interradial angles. Rays tumid at base, with the distal part roundish, slender, and uniformly tapered. Abactinal plates rather large, concealed by the cuticle, and everywhere bearing small, blunt, well-separated, simple spinules, which are more or less covered by the integument. Papulæ small, scattered singly over most of the dorsal surface. The lower marginal plates are small, somewhat prominent, and bear an irregular group of six or eight small, sharp spinules, which form a distinct border along the under edge of the disk and basal half of the rays, but disappear gradually before reaching the tips of the rays. Actinal plates entirely concealed by the integument; each one bears a divergent group of four to six or more small, sharp, rather stout spinules, which are unequal in size. Each adambulacral plate usually bears an obliquely transverse row of about five somewhat long, subacute spinules, of which the middle ones are a little longer than the others, and in some cases the row is double; the innermost is borne upon the inner angle of the plate, which projects somewhat into the furrow. The ambulacral feet are large, biserial, and furnished with well-developed terminal suckers. The inner end of each jaw bears four rather stout, sharp spines, similar to those of the adambulacral plates.

A single specimen (No. 8140) was taken at station 2226, off Delaware Bay.

Two allied species (*R. Murrayi* Sl. and *R. tumidus* (Stuxb.) Sl. are found at moderate depths on the northern European coast; the last also occurs in the Arctic Ocean.

Family ASTERINIDÆ.

ASTERINA PYGMÆA Verrill.
This Journal, vol. xvi, p. 372, 1878.

B. range, 52 to 92 fath., Gulf of Maine. Allied species are found in nearly all seas.

TREMASTER MIRABILIS Verrill.
Proc. U. S. Nat. Mus., vol. ii, p. 201, 1879; Expl. by the Albatross in 1883, pl. 18, fig. 51, 1885.

B. range, 150 to 250 fath., rare. Known only from the Banks off Nova Scotia and Newfoundland, from N. lat. 47° 6′ to near George's Bank. All the specimens have been received from the Gloucester fishermen.

No other species of this remarkable genus is known.

[To be continued.]

ART. XIV.—*Lower Cambrian Rocks in Eastern California;* By CHAS. D. WALCOTT.

[Read before Geol. Soc. America, Baltimore meeting, Dec. 27, 1894.]

THE only Lower Cambrian rocks of California known to me occur in the White Mountain range of Inyo County, east of Owen's Valley, with the single exception of one small mass west of Big Pine, which is in the foothills of the Sierra Nevada. That portion of the White Mountain range lying near the Waucobi Canyon is commonly referred to as the "White Mountain range," while the portion to the south is called the "Inyo range." Prof. J. D. Whitney refers to the ranges (Inyo and White Mountain), stating that little is known of the geology except that, from Bend City for twenty-five miles north, their western base and slope seem to be made of slate and other stratified rocks generally dipping to the southwest and often much contorted. These slates are said to alternate with beds of limestone. In these rocks a single fossil was discovered, opposite Camp Independence, by Dr. Horn. This species was considered by Mr. Gabb as identical with a Triassic species which had been found in the Upper Trias of the Alps. From this Professor Whitney identified the strata along the western flanks of the Inyo and White Mountains with the rocks of Washoe, which were referred to the Trias.*

On a map issued by the California State Mining Bureau in 1891,† eight areas of limestone are indicated on the line of the White Mountain and Inyo ranges. Some of these are described in the report of the State Mineralogist for 1888.‡ In his report

* Geol. Surv. California; Geology, vol. i, 1865, p. 459.

† Preliminary Mineralogical and Geological Map of the State of California, 1891.

‡ California State Mining Bureau; Eighth Ann. Rep. State Mineralogist for 1888.

on Inyo County Mr. W. A. Goodyear, who was an assistant in the State Survey under Prof. J. D. Whitney, speaks of the Inyo and White Mountain ranges as a part of the great Paleozoic formation which occupies so extensive an area in the Great Basin. He also describes,* in the form of an itinerary, a geological exploration of parts of the range, noting the occurrence of various stratified rocks and granites.

During the summer of 1894, accompanied by Mr. F. B. Weeks, I crossed the range over the toll-road leading from Big Pine to Piper's ranch, in Fish Lake Valley, and penetrated into it from the western side in Waucobi, Black and Silver canyons.

The ascending section exposed in the ridge on the north side of Black Canyon is as follows:

1. Gray and yellowish, arenaceous limestone, occurring in low hills above the Quaternary ..... 200 ft.
2. Massive, bedded, compact, fine-grained, often saccharoidal, light-gray, siliceous and arenaceous limestone (strike N. 10° W. mag., dip 20° E.).

   At 100 feet from base of this division a dike of basalt 40 feet in thickness cuts through and displaces the limestone in the vicinity of the dike, so as to give it a dip of from 70° to 80° E. Above the dike the dip of 20° is very quickly resumed.

   At 160 feet from the base a band of white limestone occurs, which contains numerous small concretions of limestone.

   At 230 feet above the dike occurs a band of shaly limestone, which has buff-colored partings; and irregular, buff-colored, sandy laminations occur in thin layers in the thick-bedded limestone.

No. 2 may be subdivided as follows:

   a. Light-gray and white limestone ..... 500 ft.
   b. Buff and gray, more arenaceous limestone, with a band of cherty limestone 20–25 feet thick at 125 feet from its base ..... 170 ft.
   c. Gray, arenaceous limestone, cherty at top .. 115 ft.
   d. Shaly and thick-bedded, sandy limestone, cross-bedded in places, with yellowish-buff layers, also with two bands of brown, thick-bedded and shaly quartzite ..... 145 ft.
   e. Massive, bedded, coarse, arenaceous, gray limestone, passing into buff-colored and cherty beds above ..... 85 ft.
   f. Buff-colored, shaly limestone ..... 5 ft.
   g. Bluish-gray, banded limestone ..... 30 ft.

* Loc. cit., p. 290.

h. Gray, arenaceous limestone, with bands of buff-colored, mostly thick-bedded limestone	70 ft.	
i. Thick-bedded, bluish-gray limestone	10 ft.	
j. Brownish and buff-colored, calcareous sandstone, with inclosed brecciated, thin-bedded brown sandstone	5 ft.	
k. Dark, banded quartzite	30 ft.	
l. Massive, bedded, gray, arenaceous limestone	225 ft.	
Total of No. 2		1,525 ft.
3. Dark, irregular, thin-bedded, siliceous slates, with interbedded, dark, quartzitic sandstone (dip 25–30 E. mag., strike N. and S.)		635 ft.

The section is terminated at this point by a fault line.

On the north side of Silver Canyon, No. 3 is well exposed, and is estimated to have a thickness of 2,000 feet. Above this a series of limestones and calcareous and siliceous shales occurs, and some interbedded, dark, quartzitic sandstones, that extend upward 1,000 feet. Near the base a massive, bedded limestone 100 feet in thickness occurs, in which great quantities of Lower Cambrian corals (*Archæocyathinæ*) occur. This series is capped by about 200 feet of compact, thin-bedded, arenaceous argillite, with interbedded layers of dark-brown, fine-grained quartzite.

The entire section, briefly summarized from summit downward, is as follows:

4. Upper arenaceous beds	200 ft.
3. Alternating limestones and shales	1,000 ft.
2. Siliceous slates and quartzites	2,000 ft.
1. Siliceous limestones	1,700 ft.
Total	4,900 ft.

In round numbers the section exposed in the White Mountain range, between White Mountain peak and Waucobi Canyon, is 5,000 feet in thickness.

No fossils were found in the lower limestone. Numerous annelid trails occur in the lower siliceous series, and in the slaty portion near the summit heads of Olenellus were found. In places the lower portion of the upper limestone series is almost a solid bed of different forms of the *Archæocyathinæ*. *Ethmophyllum whitneii* Meek is very abundant, and the genera *Protopharetra*, *Coscinocyathus*, and probably *Archæocyathus* occur. Ethmophyllum ranges throughout the limestone series into the base of the shales in Tollgate Canyon, where it is associated with Cystidean plates and fragments of Olenellus. On the north side of Silver Canyon the Archæocyathinæ are

so abundant in the limestone that it may practically be called a Lower Cambrian coral reef. This reef was traced for nearly thirty miles, and the same types are also known to occur in the Silver Peak range, about twenty-five miles to the eastward.

So far as known to me, this is the oldest of the Cambrian faunas known in the western portion of the United States. Just what its relations to the Olenellus fauna of central Nevada and British Columbia are I am unable at present to state, except that I believe it to be older than the Olenellus fauna of central Nevada.

It is not impossible that a fauna will be found in the lower limestone, but in the hasty reconnoissance in which I was engaged, only a portion of one day was given to the examination and measurement of the section. I hope in the future to extend the study of the White Mountain range, as Mr. Fairbanks has written me that he has discovered *Fusilina cylindrica* in the southern end of the range, east of Keeler, which is about fifty miles south of Tollgate Canyon. If the section is unbroken, the Middle and Upper Cambrian and Ordovician faunas should be found before reaching the Carboniferous horizon, discovered by Mr. Fairbanks.

Art. XV.—*On the* Pithecanthropus erectus, *Dubois*,* *from Java;* by O. C. Marsh. (With Plate II.)

A recent discovery of great interest is recorded in the memoir here cited. In many respects, this discovery appears to be one of the most important since the Neanderthal skull was brought to light in 1857, and hence the main facts concerning it deserve early notice in this Journal. This memoir of forty pages contains a full description, with illustrations, of part of a skull, a molar tooth, and a femur, found in the later Tertiary strata of Java, and pertaining to a large anthropoid ape, which is believed to represent a new genus and family intermediate between the *Simiidæ* and *Hominidæ*. This would make it a veritable "missing link" between the higher apes and man, the discovery of which has so long been confidently predicted by many anthropologists.

The locality of these remains was near Trinil, in the precinct Ngawi of the Madiun province, in central Java. The three specimens, the tooth, the skull, and the femur, were

* Pithecanthropus erectus. Eine menschenaehnliche Uebergangsform aus Java. Von Eug. Dubois, Militairarzt der niederlaendisch-indischen Armee. Mit zwei Tafeln und drei in den text gedruckten Figuren. 4to, Batavia, 1894.

1.

P Hs

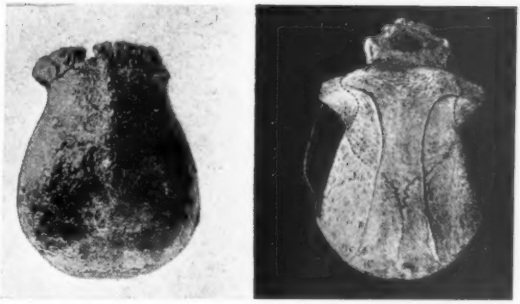


FIGURE 1.—P. Cranium of *Pithecanthropus erectus*, $\frac{1}{6}$.
Hs. Skull of *Hylobates syndactylus*, $\frac{1}{3}$. (After Dubois.)

3.

P H

a *b* *a* *b*

FIGURE 3.—P. Left femur of *Pithecanthropus erectus*, $\frac{1}{6}$.
H. Left femur of man, $\frac{1}{4}$. *a*, front view; *b*, exterior view. (After Dubois.)

found at different times, in the same horizon, and all imbedded in the same volcanic tufa. The tooth was found first, in September, 1891, in the left bank of the river Bengawan, about a meter below the water level of the river during the dry season, and twelve or fifteen meters below the plain in which the river had cut its bed. A month later, the skull was discovered, only a meter distant from the place where the tooth lay, and both apparently pertained to the same individual. In August, 1892, the left femur also was found, about fifteen meters distant from the locality where the other specimens were imbedded. Subsequent researches in the vicinity, for additional remains, were unsuccessful.

The fossils thus secured have been carefully investigated by Dr. Dubois, who regards them as representing a distinct species and genus,* and also a new family, which he names the *Pithecanthropidæ*, and distinguishes mainly by the following characters:

Brain cavity absolutely larger, and, in proportion to the size of the body, much more capacious than in the *Simiidæ*, yet less so than in the *Hominidæ*. Capacity of the skull about two-thirds the average of that of man. Inclination of the nuchal surface of the occiput considerably greater than in the *Simiidæ*. Dentition, although somewhat specialized, still of the simian type. Femur equal in its dimensions to that of man, and like that adapted for walking in an upright position.

Of this skull, the upper portion alone is preserved, the line of fracture extending from the glabella backward irregularly to the occiput, which it divides somewhat below the upper nuchal line. The cranium seen from above is an elongated oval in outline, dolichocephalic; and is distinguished from that of other anthropoid apes by its large size and its higher arching in the coronal region, as shown below in figure 2. The greatest length from the glabella to the posterior projection of the occiput is 185^{mm}. The greatest breadth is 130^{mm}, and the smallest, behind the orbits, is 90^{mm}. The cranium in its original condition must have been of somewhat larger dimensions. The upper surface of the skull is smooth, and the sutures all appear to be obliterated.

This dolichocephalic skull, with an index of 70°, is readily distinguished from that of the Orang-utan, which is decidedly brachycephalic. The absence of the characteristic cranial crests will separate it from the skull of the adult Gorilla. In

*The generic name used (*Pithecanthropus*) has already been employed by Haeckel, in 1868, for a hypothetical form, which walked erect, and had a greater intellectual development than the anthropoid apes, but did not possess the faculty of speech.

its smooth upper surface and general form, it shows a resemblance to the skull of the Chimpanzee, and still closer to that of the Gibbons (*Hylobates*).

A figure of the present specimen and the skull of a Gibbon for comparison are shown in figure 1, Plate II. These figures and those that follow are reproduced directly, but not all successfully, from illustrations in Dr. Dubois's memoir.

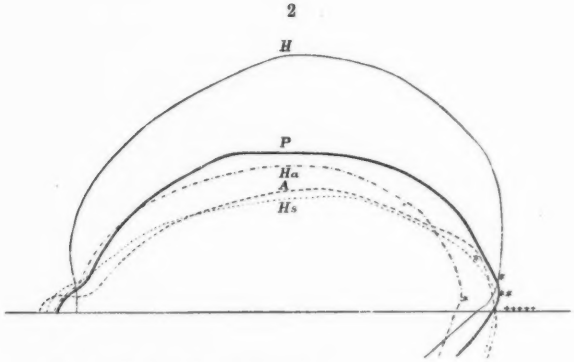


FIGURE 2.—Longitudinal outlines of crania.
H. European man; P. *Pithecanthropus;* Ha. *Hylobates agilis;* A. Chimpanzee; Hs. *Hylobates syndactylus.* (After Dubois.)

The tooth, the first specimen found, is the last upper molar of the right side, and is in good preservation. It indicates a fully adult, but not very old, animal. The crown is subtriangular in form, with the corners rounded, and the narrowest portion behind. The antero-posterior diameter of the crown is 11·3^{mm}, and the transverse diameter 15·3^{mm}. The grinding surface of the crown is concave, and much less rugose than in existing anthropoid apes.

The femur, which is from the left side, is in fair preservation, although it was somewhat injured in removing it from the surrounding rock. It belonged to a fully adult individual. In form and dimensions, it resembles so strongly a human femur that only a careful comparison would distinguish one from the other. The bone is very long, its greatest length being 455^{mm}. The shaft is slender and nearly straight. The general form and proportions of this femur are shown in figure 3, Plate II, with a human femur for comparison.

These precious remains, the skull, tooth, and femur, are described by Dr. Dubois, with full details, and for these the anatomical reader will look to the memoir itself. The conclusions drawn by the author from these fossils are so comprehensive, that they will be carefully weighed by anthropologists of every nation. It is only justice to Dr. Dubois and his admirable memoir to say here, that he has proved to science the existence of a new prehistoric anthropoid form, not human indeed, but in size, brain power, and erect posture, much nearer man than any animal hitherto discovered, living or extinct.

The brief review here given of the main facts relating to this discovery, together with the figures reproduced from the memoir, will afford the reader some idea of the importance of this latest addition to the known allies of primæval man, if not to his direct ancestry. Whatever light future researches may throw upon the affinities of this new form that left its remains in the volcanic deposits of Java during later Tertiary time, there can be no doubt that the discovery itself is an event equal in interest to that of the Neanderthal skull.

The man of the Neander valley remained without honor, even in his own country, for more than a quarter of a century, and was still doubted and reviled when his kinsmen, the men of Spy, came to his defense, and a new chapter was added to the early history of the human race. The ape-man of Java comes to light at a more fortunate time, when zeal for exploration is so great that the discovery of additional remains may be expected at no distant day. That still other intermediate forms will eventually be brought to light no one familiar with the subject can doubt. Nearly twenty years ago, the writer of the present review placed on record his belief that such missing links existed, and should be looked for in the caves and later Tertiary of Africa, which he then regarded as the most promising field for exploration in the Old World. The first announcement, however, has come from the East, where large anthropoid apes also survive, and where their ancestors were doubtless entombed under circumstances favorable to early discovery. The tropical regions of both Asia and Africa still offer most inviting fields to ambitious explorers.

Yale University, New Haven, Conn., January 21, 1895.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

Chemical Abstracts.

1. *On a new mode of preparing Hydrogen phosphide.*—The supposition that phosphorus does not combine with hydrogen directly, founded on the early experiments of Fourcroy and Vanquelin, has been shown by Retgers to be erroneous. After he had established the great readiness with which arsenic unites with moderately heated hydrogen, he inferred that ordinary phosphorus would also combine with this gas, were it not for its low fusing point, 44°. He was led, therefore, to use red phosphorus, whose melting point is much higher. And he found that when dry hydrogen is passed over red phosphorus contained in a glass tube, at a gentle heat, direct combination readily takes place and the issuing gas inflames spontaneously in the air. Evidently the non-spontaneously-inflammable gaseous phosphide of hydrogen must contain a certain amount of spontaneously-inflammable liquid phosphide; and by conducting, the evolved product through a U-tube placed in a freezing mixture, this latter phosphide was obtained separately. In addition, the solid phosphide is also produced and is deposited as a yellow mass just beyond the heated portion of the tube. On removing the source of heat, the evolved gas soon ceases to take fire on contact with the air and is almost pure hydrogen. The author thinks this process much preferable to the older methods of preparing hydrogen phosphide, not only because of the ease with which it may be operated, but also because it affords an excellent example of the formation of the three hydrogen phosphides by direct synthesis.—*Zeitschr. anorg. Chem.*, vii, 265, September, 1894. G. F. B.

2. *On a Hydrate of Sodium Trioxide.*—By the action of ordinary alcohol upon sodium peroxide, Tafel has obtained a new substance of rather remarkable composition. When the alcohol is poured on the peroxide, a part of the latter enters into combination to form a strongly alkaline solution, while the rest, about equal to this in amount, changes its color from pale yellow to pure white and becomes a fine granular powder, totally unlike the peroxide in appearance. It is soluble in water, but with much less rise of temperature. While the peroxide is stable even at high temperatures evolving no oxygen below redness, the new substance evolves oxygen copiously on simple warming; and if heated rapidly in a test tube explodes violently with the production of flame. If the dry powder be touched with a heated rod, the escaping oxygen sets the particles into a rapid whirling motion, with a very considerable rise of temperature; the action extending throughout the entire mass, pure dry oxygen being continuously evolved. On heating still more strongly, the residue melts and evolves vapor of water, leaving ordinary sodium hydrate. On analysis it afforded

the composition $HNaO_2$, being formed according to the equation:

$$Na_2O_2 + C_2H_5OH = C_2H_5ONa + HNaO_2$$

The author regards the new substance as the hydrate of sodium trioxide, Na_2O_3; and therefore gives it a doubled formula, $H_2Na_2O_4$. In ice-cold water it dissolves unchanged, but at higher temperatures the solution slowly evolves oxygen. If alcohol be present, the evolution of gas increases and the solution deposits crystals of the hydrate of sodium peroxide $Na_2O_2(H_2O)_2$, discovered by Vernon Harcourt. By hydrogen chloride, it is converted into sodium chloride, hydrogen peroxide and oxygen gas. In preparing this new substance, the author finds 12 grams sodium peroxide and 200 c.c. of ice-cold absolute alcohol, convenient quantities to employ. After shaking them well together, the liquid is filtered off, and the white sandy product—separated from any undecomposed peroxide—is washed with cold alcohol and ether and placed in a desiccator.—*Ber. Berl. Chem. Ges.*, xxvii, 2297, September, 1894. G. F. B.

3. *On a pure white Stannic sulphide.*—A new form of tin disulphide has been prepared by Schmidt which is pure white in color and which is readily soluble in ammonium carbonate. To prepare it, metallic tin is dissolved in hydrochloric acid, and the stannous chloride is converted into stannic chloride by means of nitric acid; the excess of acid being removed by evaporation. After dilution, the tin sulphide is thrown down by hydrogen sulphide in the ordinary yellow form. It is washed, separated from traces of arsenic by solution in hydrogen chloride and reprecipitation, and digested with ammonium hydrate in excess for some days. The clear solution is neutralized with dilute sulphuric acid, when an almost pure white precipitate is obtained. On dissolving this in ammonium carbonate and neutralizing with sulphuric acid the precipitate is pure white. It is very bulky and is in a different state of hydration or of molecular aggregation from ordinary stannic sulphide. Upon drying it becomes amber-yellow and is no longer soluble in ammonium carbonate.—*Nature*, li, 85, November 1894. G. F. B.

4. *On the Properties of Liquid Ethane and Propane.*—The properties of the gaseous hydrocarbons ethane and propane in the liquefied condition have been studied by Hainlen in Lothar Meyer's laboratory. The propane was obtained pure by the process of Köhnlein which consists in heating propyl iodide to 130° in a sealed tube with aluminum chloride. After twenty hours, the tube was allowed to cool and was afterwards placed in a freezing mixture; it could then be opened without danger and the gas be transferred to a gas-holder. It was condensed to a liquid in a U-tube surrounded with solid carbon dioxide, and then was distilled over into a special boiling point apparatus, which consisted of a glass tube closed at the lower end, having a side tube by which the gas entered, and provided at top with a stopper through which a thermometer and the exit tube passed. Solid carbon dioxide surrounded the upper half of this tube and a layer

of felt the lower half; the propane condensing above and collecting below. By removing the felt the liquid boiled, at first irregularly; but it finally became steady and the corrected temperature-reading was found to be $-37°$ at 760^{mm}. The vapor pressures at different temperatures from $-33°$ to $+12·5°$ were determined by placing the liquid propane in one leg of a U-tube and air in the other; the two being separated by mercury and the pressure estimated from the compression of the air. From $12·5°$ to $102°$ the pressure was measured in a Cailletet apparatus. It was found that at $-33°$, the pressure was 1·8 atmospheres; at $-19°$, 2·7; at $-15°$, 3·1; at $-11°$, 3·6; at $-5°$, 4·1; at $-2°$, 4·8; at $+1°$, 5·1; at $5·5°$, 5·9; at $12·5°$, 7·1; at $22°$, 9; at $53°$, 17; at $85°$, 35; and at $102°$, 48·5 atmospheres. The critical temperature of propane is $102°$ and the corresponding critical pressure 48·5 atmospheres. Hence, propane may be sealed safely in glass tubes when surrounded with solid carbon dioxide, and thus preserved. It is colorless and much more viscous than liquid carbon dioxide. Its density at $0°$ is 0·536, at $6·2°$, 0·524, at $11·5°$, 0·520, and at $15·9°$, 0·515. The examination of liquid ethane was more difficult owing to its lower boiling point. The gas was prepared from ethyl iodide and the zinc-copper couple of Gladstone and Tribe. Although a mixture of solid carbon dioxide and ether was found insufficient to liquefy ethane, liquid ethylene afforded the necessary low temperature and the ethane readily condensed to a liquid in the boiling point apparatus, where its temperature was determined by means of a thermo element. When in regular ebullition, its boiling point was found to be $-89·5°$ at 735^{mm} pressure. The determination of the pressure at different temperatures was effected in a modified Cailletet apparatus. The critical temperature was found to be $34·5°$ and the critical pressure 50 atmospheres. The meniscus became hazy at $32°$ and disappeared completely only at $40°$. At $31°$, the pressure is 11 atmospheres; at $-20°$, 14·5; at $-11°$, 18·3; at $0°$, 23·3; at $+15°$, 32·3; and at $+34·5°$, 50. The density of liquid ethane at $0°$ is 0·446, and at $10·5°$, 0·396.—*Liebig's Annalen*, cclxxxii, 229, October, 1894. G. F. B.

5. *On the Effect of Low Temperatures on Chloroform.*—An interesting example of the anomalous behavior of substances at very low temperatures has been observed by Raoul Pictet in the case of chloroform. In the preparation of this substance in the pure state by crystallization at $-69°$ he made use of two copper refrigerators, of capacities of 2½ and 32 liters respectively. In the first series of experiments, the former only was used. About 2 kilograms of commercial chloroform in a glass cylinder was placed in the refrigerator and cooled to $-120°$, as indicated by an ether thermometer. The chloroform appeared turbid at $-40°$ or $-50°$, and was filtered and again cooled. At $-68·5°$, the cooling ceased and very transparent crystals of chloroform appeared on the walls of the tube. Owing to the anæsthetic advantages of the pure chloroform thus obtained, attempts were

made to secure larger quantities, by operating in the larger vessel. But it was found that here the chloroform could be cooled to −81° without a trace of crystallization. Indeed chloroform crystals produced in the smaller vessel at −68·5°, dissolved at once when placed in the larger one at −81°. Finally the whole tube with crystals on its walls and liquid surrounding them, was immersed at −68·5° in the liquid chloroform at −81°. And although the thermometer fell from the higher to the lower temperature, the crystals actually dissolved before the observer's eyes. The author accounts for this result on certain theories of his own concerning radiation.—*Nature*, li, 20, November, 1894. See also *C. R.* cxix, 554, 1894. G. F. B.

6. *On Symmetrical Di-ethyl hydrazine.*—Although the discoverer of hydrazine, Curtius, succeeded in obtaining the symmetrical di-benzyl hydrazine and Fischer the unsymmetrical di-ethyl hydrazine, yet it is only recently that the symmetrical di-ethyl derivative of hydrazine $C_2H_5NH.NHC_2H_5$, or symmetrical hydrazo-ethane, has been isolated. This has been done by HARRIES in the laboratory of the University of Berlin, by a somewhat indirect though in practice quite simple series of reactions. As the first step, a remarkable hydrazine derivative was first prepared by acting on di-formyl hydrazine with sodium and then decomposing the product with lead acetate. In this derivative one hydrogen atom of each amidogen radical was replaced by the radical formyl and the other by lead; its constitution being $\begin{matrix}CHO-N\\ \\ CHO-N\end{matrix}\!\!\diagdown\!\!\diagup Pb$. When warmed in a sealed tube with ethyl iodide, together with sand and magnesia, the lead atom is replaced by two ethyl groups. The substance thus obtained, a volatile liquid, is then treated with fuming hydrogen chloride, which removes the formyl groups and produces the hydrochloride of symmetrical di-ethyl hydrazine; the free substance passing over at 85° on distillation with potassium hydrate. It is a liquid with an agreeable ethereal odor which reduces Fehling's solution with great energy and also silver nitrate even in the cold. Toward certain oxidizing agents, especially yellow mercuric oxide, it reacts violently, yielding mercury di-ethyl and azoethane $C_2H_5N{=}NC_2H_5$.—*Ber. Berl. Chem. Ges.*, xxvii, 2276, September, 1894. G. F. B.

7. *On Carbazide and Di-urea.*—In conjunction with CURTIUS, HEIDENREICH has produced two remarkable nitrogen compounds, one of which is carbazide or carbonyl nitride CON_6 and the other is di-urea $CO(NH.NH)_2CO$. The former is produced by the action of sodium nitrite on the hydrochloride of carbohydrazide. It is a colorless oil which explodes violently on being touched. The latter is obtained when the compound $\left\{\begin{matrix}NH{\cdot}COOC_2H_5\\ NH{\cdot}COOC_2H_5\end{matrix}\right.$ is heated to 100° with hydrazine hydrate in a sealed tube. It is crystalline and very stable and acts like a strong monobasic acid. —*Ber. Berl. Chem. Ges.*, xxvii, 2684, October, 1894. G. F. B.

8. *Phosphorescence at Low Temperatures.*—RAOUL, PICTET and ALLSCHUL exposed tubes containing sulphides of calcium, strontium and barium to a strong sunlight for definite periods of time and then placed them in liquid nitrous oxide, the temperature of which was estimated at −140°. After remaining in the freezing mixture for twelve minutes they were taken out and the renewal of the phosphorescent appearance was observed. At first no light could be observed, gradually, however, light appeared in the warmer portions of the tubes and extended to lower portions. After five minutes the tubes became as bright as they were before they were placed in the freezing mixture. To determine the limits of the phenomena the tubes were placed in alcohol cooled to −80°, as the tubes took the temperature of the alcohol the phosphorescence diminished and totally disappeared at −65°. The portions of the tube above the alcohol phosphoresced strongly. Before the colored phosphorescence, whether blue, green or orange, entirely disappeared, the tubes assumed a yellow color.—*Zeitschrift fur physikalishe Chemie*, vol. xv, part 3, p. 386. J. T.

9. *Telegraphing without wires.*—At a meeting of the Physical Society held in Berlin, Nov. 16, Professor Rubens gave an account of experiments on this subject. On the banks of the Wannsee near Potsdam two electrodes were sunk in the water at a distance of 500 meters from each other and a current of fifty-five accumulators was sent through them. From each of the boats connected by a cable an electrode was immersed in the water and a telephone inserted into the connection. When the current of the accumulators was broken an effect was perceived in the telephone at a distance of 4·5 kilometres. Small islands lying between the boats and the shore had no influence on the transmission of the signals.—*Nature*, Dec. 20, 1894. J. T.

10. *Calculation and measure of small coefficients of Self-induction.*—In the study of electric waves, the oscillators and resonators have, in general, small coefficients of self-induction and it becomes important to obtain an accurate value of these coefficients. Max Wien discusses the various mathematical formulæ for parallel wires, circles, rectangles, etc., and gives an experimental method also of determining the values of the coefficients. The student will find an interesting use of Maxwell's geometrical mean distance in the paper.—*Ann. der Physik und Chemie*, No. 13, 1894, pp. 928–947. J. T.

11. *Self-induction in iron wires.*—KLEMENCIC shows that in general the magnetic permeability is different in the circular and axial directions. Iron wires may be said to be magnetically double refracting. In soft iron the permeability is smaller around the axis than in the direction of the axis. Hard iron in the process of drawing, obtains a stronger permeability axially than in the circular direction. This is also the case with Bessemer steel.—*Ann. der Physik und Chemie*, No. 13, 1894, pp. 1053–1061.

J. T.

12. "*On the Photographic Spectrum of the Great Nebula in Orion*," by J. NORMAN LOCKYER, C.B., F.R.S. Abstract from the Proc. Roy. Soc., lvi., 285.—The paper consists of a description and discussion of photographs of the spectrum of the Orion Nebula, taken with the 30 inch reflector at Westgate-on-Sea in February, 1890, of which a preliminary account was communicated to the Royal Society at the time. Fifty-four lines are tabulated as belonging to the spectrum of the nebula, nine of them being due to hydrogen. The complete discussion has led to the following general conclusions:—

1. The spectrum of the nebula of Orion is a compound one consisting of hydrogen lines, low temperature metallic lines and flutings, and high temperature lines. The mean temperature, however, is relatively low.*

2. The spectrum is different in different parts of the nebula.

3. The spectrum bears a striking resemblance to that of the planetary nebulæ and bright line stars.

4. The suggestion, therefore, that these are bodies which must be closely associated in any valid scheme of classification, is confirmed.

5. Many of the lines which appear bright in the spectrum of the nebula appear dark in the spectra of stars of Groups II and III; and in the earlier stars of Group IV, and a gradual change from bright to dark lines has been found.

6. The view, therefore, that bright line stars occupy an intermediate position between nebulæ and stars of Groups II and III is greatly strengthened by these researches.

13. *Elementary Lessons in Electricity and Magnetism* by SILVANUS P. THOMPSON. New edition, revised throughout with additions, 628 pp. New York and London, 1895 (Macmillan & Co.)—The first edition of Thompson's Lessons, published in 1881, is well known as one of the best elementary books on Electricity and Magnetism ever presented and, with later reprints, it has had well deserved success. The present new edition contains all the good features of the earlier ones, while the large amount of new matter added makes it fresh and new throughout. Thus for example, to the subject of Electric waves a special chapter is devoted in which the work of Hertz and others is clearly, if briefly, presented. Many new illustrations are introduced; these representing the lines of force in various electric fields, e. g. in electrostatic induction, etc., will be particularly helpful to the student. The work in its present form deserves high commendation. A criticism might be offered by the teacher using the book to the arrangement of matter in some cases, but there may be room here for some difference of opinion.

* Roy. Soc. Proc., vol. xlii, p. 152, 1887.

II. Geology and Mineralogy.

1. *Note on the Florida Reef;* by A. Agassiz. (Letter to J. D. Dana dated Tampa Bay, Florida, Dec. 27, 1894)—You will be interested to hear that I have just returned from a ten days' trip to the Florida reefs, which I was anxious to examine again, in the light of the experience gained by my visit to the Bahamas and Bermudas; I think I shall be obliged materially to change my ideas of the mode of formation of the Keys, and to give up the Marquesas as a true Atoll. After having seen at the Bermudas the mode of formation of the Sounds, I have become satisfied that the Marquesas are a Sound. But the Florida Sounds do not, I think, owe their origin to subsidence, but merely to the mechanical and solvent action of the sea. It is interesting to trace on the large scale charts of the Coast Survey the mode of formation of Key Biscayne Bay, composed of two sounds, followed by Barns Sound, and finally to the westward, by the Bay of Florida, itself only a series of disconnected sounds indicated by isolated keys and bars. The same thing is going on at the Pine Islands, Key West, Boca Chica, Boca Grande, Ballast Key, and is especially well seen in Key Largo, the Marquesas, to the west of the principal line of Keys being a remarkably well preserved sound of an elliptical shape. To my great surprise I found that Lower Matecumbe was edged by an elevated reef about 2 feet above high water mark! and this elevated reef I was able to trace all along the shores of the Keys to the east of Indian Key as far as Soldiers Key, off the central part of Key Biscayne. I examined this elevated reef also at Indian Key where its highest point is 8 feet above high water mark, at several points on Key Largo, Old Rhodes, Elliott Key, and, as the most easterly point, Soldiers Key. No trace of this elevated reef could be detected north of Cape Florida, Key Biscayne being entirely covered by siliceous sands, just as the beaches of limestone sands cover great tracts of the Keys to the westward and hide the underlying elevated reef. Shaler speaks of having traced this reef at Old Rhode's and having followed it to the Miami River as an elevated reef. I was quite surprised on examining a bluff about ten feet in height, extending eastward from Cocoanut Point toward the mouth of the Miami River, to find that it consisted of *æolian rocks* which have covered the elevated reef in many places. On the low shores these æolian rocks are honeycombed and pitted and might be readily mistaken for decomposed reef rocks; but they contain *no* corals. This looks as if the lower southern extremity of Florida, the Everglade tracts, was a huge sink into which sands had been blown forming low dunes which have little by little been eroded, and which former observers had mistaken in some localities for reef rock. The material for these dunes coming from the (now elevated) reef at a time when it was either a fringing or a barrier reef along the former coast line of Florida, all of which, back of the reef, has little by little been eroded

by the mechanical and solvent action of the sea leaving only an occasional outcrop of the elevated reef as observed by Agassiz and Shaler. The outer line of reef has also been elevated. For I think Tuomey was right in looking upon the outcropping reef rock of Sand Key as an elevated reef, if I remember rightly what he says; while Professor Agassiz mistook it, as well as the traces of the elevated reef he saw along some of the Keys, for a recent reef consisting of beach rock into which large masses of corals had been thrown by hurricanes. But in this I now think both he and I were mistaken. It was however a natural view to take of the formation of that reef for one who was not familiar with the peculiar aspect of the elevated reefs of Cuba. From the Pine Keys and the Islands to the West, and including the Marquesas, there is nothing exposed but beach rock, stratified at a slight angle seaward on the sea faces of these Keys; and even that is only casually exposed,—the greater part of the southern beaches of the Keys being covered by coralline and coral sand completely hiding the substratum. Behind this beach rock, æolian rocks stretch northward and have formed the Keys.

2. *The Geological Society of America.* 7th Annual meeting.—The winter meeting of the Geological Society was held in Baltimore Dec. 27, 28, and 29, 1894, in the geological rooms of the Johns Hopkins University. It was a representative gathering, geologists from all parts of the county east of the Rocky mountains attending; and the number of papers presented for reading (48) was so great that it was found necessary to make two sections in order to have them all read during the meeting. The Presidential address was delivered in Levering Hall at the evening session and was one of the most important contributions of the meeting. It was an account of his recent glacial studies in Northern Greenland, by Professsor T. C. Chamberlin as a member of the Peary expedition which went to Greenland during the last summer. The lecture was illustrated with some sixty stereopticon slides. "The feature that first impresses the observer on reaching the glaciers of the far North," said the lecturer, "is the verticality of their walls. Southern glaciers terminate in curving slopes. Next to the verticality of the edges, the most impressive feature is the pronounced stratification of the ice. It appears that stratification originated in the nucleus of deposition, emphasized by winds, rains and surface melting; that the extended stratification may have been intensified by the ordinary processes of consolidation; that shearings of the strata upon each other still further emphasized the stratification and developed new horizons under favorable conditions; that basal inequalities introduced new planes of stratification, accompanied by earthy debris, and that this process extended itself so far as even to form minute laminæ. A glacier is, essentially, made up of large, interlocking granules that have been developed from the snow crystals and pellets of the original snowfall. In the growth and the changes of these granules the secret of motion may lie. The glaciers drop

their material in front, and so sometimes build up their own pathway before them; thus, it is easy to understand how they may advance over sandy soils without abrading or disrupting them. All along the coast, from Southern Greenland to Inglefield Gulf, there are stretches of mountains that are very angular and irregular, and show no evidences of ever having been overridden by the ice. There are other stretches of the coast that seem to have been once covered by the ice, as their contours are subdued. It would appear, therefore, that the ice once pushed out to the coast line a portion of the western coast, and failed to do so along the other portion. The general conclusion is that no great extension of the Greenland ice has formerly taken place, and, hence, that the theory that the glaciation of our own region had its source in Greenland is without support."

G. F. WRIGHT, presented a paper on *Observations on the Glacial Phenomena of Newfoundland, Labrador and Southern Greenland* which is given in full in this Journal. H. F. REID discussed *Variations in velocity of glaciers* incident to varying amount of snow, pointing out vividly the effect of decrease in snow-fall in the withdrawal of the ice front with increasing rapidity, while increase of snow fall would result in advance of the glacier beginning only after considerable accumulations to the mass, and increasing in rate of advance as the increased snow fall continued. C. H. HITCHCOCK spoke on *Highland level gravels in northern New England*, which he interpreted as evidence of glacial lake beaches, 1000 and more feet in altitude in New Hampshire. WARREN UPHAM read papers on *Discrimination of glacial accumulations and invasion*, and *Climatic conditions shown by North American interglacial deposits.* Two papers based upon study of the altitudes of old beach lines and morainal drift in New York State were read by H. L. FAIRCHILD, of which the following abstracts are communicated by the author.

Glacial Lakes in western New York, Lake Newberry, the successor of Lake Warren, by H. L. FAIRCHILD.—If the reader will place before himself a map showing the hydrography of western and central New York, he will observe that the divide between the St. Lawrence and the Ohio-Susquehanna waters passes near the south ends of the so-called "Finger Lakes." The valleys of these present lakes with their northward drainage end abruptly in the high land south, the old valleys in that direction being choked with moraine drift. The same is true of several other valleys between the Tonawanda on the west and the Onondaga on the east, in which no water is now ponded.

All these north-south valleys were, during the retreat of the ice sheet, the site of extinct lakes, the water of which was held up by the barrier of ice on the north to the height of the col south, and so forced into southern drainage. Granting the capacity of glacial ice to serve as barrier to water, only a glance at the topography is sufficient to show the the necessity of such lakes. The positive evidence is found in the abandoned stream channels south

of all the cols, the terraces and water inscriptions upon the valley sides north of the cols, and particularly the many large deltas formed by the lateral streams debouching into the extinct lakes at the high levels.

Eighteen of these extinct lakes are recognized from the topography, the Attica lake (the flooded Tonawanda valley) being the most western, and the Tully valley lake (the flooded Onondaga valley) the most eastern. Data have been gathered by personal observation and measurements of several of the more important lakes. The Ithaca lake was the largest and deepest, being at its maximum over 1100 feet deep, five to ten miles wide and about thirty miles long, overflowing by the Six Mile Creek and Catatonk valleys to the Susquehanna at Owego. The Watkins lake with its outlet by Horseheads to the Chemung at Elmira was in dimensions but little under the Ithaca lake. A fine delta at Watkins gives the maximum level of the water and several lower levels. The Dansville, the Conesus, the Naples, and the Hammondsport lakes have been carefully studied. Some of these have a complex but interesting history.

With the removal of the ice barrier by the melting and recession of the ice, the local glacial lakes were lowered until they were merged into the great body of glacial water which buried all western New York, north of the dividing ridge, to a depth of several hundred feet. At first this was the "Warren" water, having its outlet at the low divide south of the present Lake Michigan, near the site of Chicago. The beaches of this water have been traced by Mr. Gilbert, Mr. Spencer and Mr. Leverett to a point east of Buffalo, and at an elevation of 860 feet or more, with a differential rise toward the northeast. This indicates a depression of western-central New York following the ice-retreat. If Messrs. Upham and Spencer are correct in their estimates of the depression, then the Horseheads outlet of the glacial Watkins lake was certainly below the Chicago outlet of the Warren waters, and the uncovering of the Seneca Valley gave a new and lower outlet. There could have been no other escape for the waters unless there was a low uncovered pass into Hudson's Bay, which is not believed. In memory of a former distinguished worker in the field of glacial geology this lower lake is called Lake Newberry.

The further withdrawal of the ice sheet finally uncovered the valley of the Mohawk, and opened a still lower outlet, producing the episode of Lake Iroquois.

R. D. Salisbury read a paper on "*The Surface Formations of Southern New Jersey.*" The following abstract was prepared by him for this Journal. The series of deposits considered in this paper have heretofore been grouped under the name of "Yellow Gravel." It is found that the series of sands and gravels which have been referred to by this general name are divisible into several distinct formations. Of these formations there are certainly three, probably four, and possibly five. The oldest of these sev-

eral formations finds its northernmost extension in the Sand Hills north of Monmouth Junction. It caps various high hills in Monmouth County, where it reaches its greatest elevation. Southward the formation becomes lower and at the same time much more continuous. In general it is essentially continuous south of the line where the Middle Marl bed comes to the surface. This formation has essentially the same dip as the Cretaceous beds beneath. That it is not strictly conformable with the Cretaceous is shown by the fact that it overlies different members of the Cretaceous series in different areas. The relations are such as to show that the main part of the deformation of the Cretaceous beds took place after this oldest "Yellow Gravel" formation was laid down. Professor W. B. Clark has reached the conclusion that this formation is Miocene. After it was deposited, there was a period of uplift accompanied by deformation. This was followed by a long period of erosion, during which a large part of the formation, especially to the north, was destroyed by subaërial agencies. During this time of erosion central Jersey was reduced to a peneplain. Subsequently the central and southern parts of Jersey were again submerged, and there was deposited on the peneplain, the second member (the Pensauken formation) of the "Yellow Gravel" series. Above the Pensauken sea stood a considerable number of hills capped by Miocene. The Pensauken is best developed along the trough-like depression which extends from the vicinity of Trenton northeastward to Raritan bay. The Pensauken formation is made up of constituents which came from very diverse sources. The Triassic shale, and most, if not all the formations of the highlands of northern New Jersey made their contributions, as well as the Cretaceous and Miocene. All decomposable constituents of the formation are completely decayed. This formation originally reached at least as far north as the Watchung Mountains. During the uplift which followed the deposition, there was slight deformation, the elevation being greatest in the region which suffered greatest uplift after the deposition of the Miocene beds. Erosion followed, and a well developed system of drainage was established on the Pensauken surface. Subsequently subsidence and a considerable degree of submergence followed, so that much of the Pensauken formation (its lower parts) and the valleys which were cut in it, received a new mantle of loam and gravel. This is known as the Jamesburg formation. Subsequent to the deposition of the Jamesburg, the Trenton gravels were deposited in the Delaware valley, during the last glacial epoch which affected New Jersey. About the eastern and southern coasts of the state there is a broad, ill defined terrace, having a general altitude of about forty-five feet, which may or may not correspond in age with the Trenton gravels. This broad terrace is certainly much younger than the body of the Jamesburg formation, though it may represent no more than a halt in the emergence which followed the deposition of the body of that formation. The correlation of these various subdivisions

with formations which have been heretofore recognized is not now attempted. There is some reason to believe that the Pensauken is considerably older than the oldest glacial drift. The two formations come together in but one area, and there the relations are not unequivocal. The general constitution of the Pensauken formation would ally it quite as closely with the Lafayette as with the Columbia of the regions farther south, but this is not regarded as a sufficient basis for so correlating it. It may be Pleistocene, antedating the earliest drift by a short interval only. The Jamesburg formation contains occasional glaciated bowlders. It is believed to be later in origin than the earliest glacial drift, and to be earlier than the latest glacial drift. Little erosion has taken place since it was laid down. Whether this is the result of a shortness of time, or of insufficient elevation, is not yet certain.

C. D. WALCOTT, in a paper on *The Appalachian type of folding in the White Mountain Range, of Inyo County, California*, gave an account of the discovery of the overturned synclinal-anticlinal structure in the White Mountain range, situated east of the Sierras, similar to that existing in the Appalachian Mountains in occupying a similar position to those on the opposite side of the continent. In a second paper (*Lower Cambrian Rocks in Eastern California*), he gave an account of the discovery of Lower Cambrian rocks and fauna in the same range. These two papers will appear in full elsewhere in this Journal. ARTHUR KEITH gave an interesting analysis of the structure of the Southern Appalachians in a paper on *New structural features in the Appalachians*. His paper reviewed the generalizations of long standing in regard to Appalachian structure, stated and analyzed the late generalizations, such as effect of bedding planes, of superincumbent lead, of initial basins of deposit, and of transmission of thrust, upon structure. Finally, statement was made of newly discovered structures, such as fan structure, cross folds, cross shear zones, secondary system of folding and the distribution of metamorphism; and a theory was advanced to account for these features that the crystalline rocks moved against the sediments, chiefly along the shear-zones, and deformed them most in the southwestern Appalachians.

F. B. ADAMS presented an excellent paper entitled *A further contribution to our knowledge of the Laurentian*, which was fully illustrated by lantern views with the novelty of projecting the enlarged rock sections directly upon the screen. Prof. Adams showed that essentially two types of rock structure are to be found in the metamorphosed Laurentian rocks, one a purely clastic one, the other one in which recrystallization has taken place and the importance of these in discriminating the origin of these rocks was pointed out.

G. K. GILBERT, in a paper on *the formation of lake basins by wind, The Tepee Buttes*, by G. K. GILBERT and F. P. GULLIVER, described peculiar geological formations examined by him in Colorado. Shallow lakelets reaching ½ a mile in greatest diameter, were observed in the arid regions in eastern Colorado along the

Arkansas River valley, often near the highest points in the surface topography, and were interpreted as hollows scooped out by winds blowing in one direction persistently, during dry weather and filled by rains, becoming lakes and finally drying up to mere hollows in the surface. The name "Tepee Buttes" is given to conical hills left after surface degradation of the approximately horizontal Cretaceous strata, composed of central cylindrical cones of limestone chiefly made up of fossil shells in the midst of the soft, thinly bedded shales. N. S. SHALER read a paper *On certain features in the jointing and veining of the Lower Silurian limestone near Cumberland Gap, Tenn.*,—gash veins, in dense dolomitic limestone, 1^{mm}. in diameter and an inch to a few inches in length, filled by calcite, but the rock strata not faulted, folded or displaced. H. S. WILLIAMS, read a paper on *Devonian fossils in Carboniferous strata* which appears in full in the present number of this Journal. The large number of papers on Petrography and allied subjects determined the formation of a petrographical section which held a separate meeting on Friday.

In addition to the papers above referred to the following were presented, some of them, in the absence of the authors, being read by title only.

H. P. CUSHING—The faults of Chazy Township, Clinton Co., N. Y.

W. J. MCGEE—Remarks on the geology of Arizona and Sonora.

WALTER H. WEED and LOUIS V. PIRSSON—Geology of the Highwood Mountains, Montana.

CHARLES R. KEYES—Genesis and structure of the Ozark uplift.

J. W. SPENCER—The geographical evolution of Cuba.

T. C. CHAMBERLIN—Notes on the glaciation of Newfoundland.

C. W. HALL—The Pre-Cambrian floor in the Northwestern states.

J. F. KEMP—The crystalline limestones, ophiolites and associated schists of the eastern Adirondacks.

DAVID WHITE—The Pottsville series along New River, West Virginia.

WILLIAM B. CLARK—The Cretaceous deposits of the Northern half of the Atlantic coastal plain. The marginal development of the Miocene in eastern New Jersey.

G. K. GILBERT—Stratigraphic measurement of Cretaceous time.

E. T. DUMBLE—Notes on the Cretaceous of Western Texas and Coahuila, Mexico.

N. H. DARTON—Sedimentary geology of the Baltimore region.

R. P. WHITFIELD—On new forms of marine algæ from the Trenton limestone, with observations on *Buthograptus laxus*, Hall.

W S. BAYLEY—Spherulitic volcanics at North Haven, Maine. The peripheral phases of the great gabbro mass of northeastern Minnesota. The contact phenomena at Pigeon Point, Minnesota. (Simply exhibition of specimens.)

ALFRED C. LANE—The relation of grain to distance from margin in certain rocks. Crystallized slags from copper-smelting.

ROBERT BELL—On the honeycombed limestones in the bottom of Lake Huron.

LEON S. GRISWOLD—On the nomenclature of the fine-grained siliceous rocks.

ALFRED E. BARLOW—On some dykes containing "Huronite."

WALDEMAR LINDGREN—The characteristic feature of the California gold quartz veins.

SAMUEL WEIDMAN—On the quartz-keratophyre and its associated rocks of the Baraboo Bluffs, Wisconsin.

EDWARD B. MATHEWS—The granites of Pike's Peak, Colorado.

N. H. DARTON and J. F. KEMP—A new intrusive rock near Syracuse, New York.

G. P. MERRILL—On the decomposition of the granite rocks of the District of Columbia.

B. WILLIS—Ancient physiography as represented by sediments.

B. K. EMERSON—Serpentine pseudormorphs after olivine, formerly called quartz-pseudomorphs, Middlefield, Mass. Skeleton crystals of salt which have been called chiastolite and later spinel, from the Trias, Westfield, Mass. Radiating puckering of corundum crystals around allanite, Pelham, Mass.

C. H. SMYTH, JR.—The crystalline limestones and associated rocks of the Northwest Adirondack region. H. S. W.

3. *Manual of Geology. Treating of the Principles of the science with special reference to American Geological History;* by JAMES D. DANA. 4th edit., pp. 1088, with 1575 figures and two double-page maps. New York, 1895. (American Book Company).—Dana's Manual, in this new edition, is a wholly rewritten work, a total revision having become necessary in consequence of the great progress in the science during the last twenty years, and especially in the geology of the Continent of North America. In the Preface the author remarks that North American Geology is still its chief subject; and adds:

"The time-divisions in this history, based on the ascertained subdivisions of the formations, were first brought out in my Address before the meeting of the American Association at Providence, in 1855;* and in 1863, the 'continuous history' appeared in the first edition of this Manual, written up from the State Reports and other geological publications. The idea, long before recognized, that all observations on the rocks, however local, bore directly on the stages in the growth of the Continent derives universal importance from the recognition of North America as the world's type continent—the only continent that gives, in a full and simple way, the fundamental principles of continental development."

The general arrangement of the work remains the same as in the earlier editions, except that Dynamical Geology is made to precede Historical. Moreover the Dynamical part commences with a chapter on "Chemical Work"; and the subject of Mountain-making and Earth-shaping, with which it closes, is treated under the general heading of "Hypogeic Work," the results, whatever the agency concerned, whether external or internal, being consequent on subterranean movements.

In the preparation of the Historical part of the Manual, the author, besides availing himself of all recent geological reports and other related publications, carried on an extensive correspondence with the chief geologists of the country; and further, in the paleontological parts, each of the chief divisions of the subject was prepared with the assistance of specialists familiar with the latest results of investigation.

The following are the principal changes in connection with the subdivisions of geological time.

Paleozoic time is divided at the close of the Lower Silurian, into two sections:

* Republished. with added notes, in this Journal, II, xxii, 305, 1856.

(1) The EOPALEOZOIC, characterized by almost universal seas over the Continental areas, by the display of Invertebrate marine life under nearly all its grander divisions, and by the first appearance of marine Vertebrates—all eminently thalassic features; and by the appearance of the earliest of terrestrial plants and Invertebrates.

(2) After the making in North America of the Taconic Mountain system and the attendant raising of land above the sea along the wide Atlantic border, the NEOPALEOZOIC, characterized by the increasing emergence of the land of eastern North America, and also by the further emergence of life, until, through the progressing developments, a great semicontinent existed, that of *eastern* North America covered with forests and populated by Amphibians and Reptiles, along with gigantic Insects and various inferior species.

The Devonian era is made to commence with the Oriskany period; and the Catskill period, hitherto the last, is dropped, the deposits being now regarded by workers in the field, as a sea-shore phase of the Upper Devonian. In the first edition of this work (and still earlier in 1855), the Subcarboniferous, Carboniferous and Permian periods were made to represent one age or era, and the age was named the Carboniferous; but in this new edition, since the double use of the name Carboniferous is objectionable, Renevier's term, Carbonic, first published by him as the name of the era in 1874, is substituted. The name Subcarboniferous is retained because it has priority, D. D. Owen having formally proposed it for the period in his final quarto report, of 1852, on the Geological survey of Wisconsin, Iowa and Minnesota.

The American Cretaceous period is divided into epochs based on the Cretaceous series of Texas and the Continental Interior, which in general is sufficiently fossiliferous to serve as the basis of time-divisions. Those of the Lower Cretaceous are named the Trinity, Fredericksburg and Washita epochs, from Prof. R. T. Hill's Texas section; and those of the Upper, the Dakota, Colorado, Montana and Laramie, from the Cretaceous of the Continental Interior, after the grouping of Eldridge. Moreover the Laramie is divided into the Lower Laramie, and the Denver group or Upper Laramie.

It is brought out in this connection that Mesozoic time, like Paleozoic, ended in North America in the making of a great coal-bearing formation, and as the coal period closed there followed mountain-making on a grand scale and world-wide disappearance of species; and that further, as, after the Paleozoic, the emergence from the water of the eastern half of North America took place, so, after the Mesozoic, there was the final emergence of the western half. The Post-cretaceous mountain system of the Rocky Mountains is called the Laramide, and it is described as extending from near the Arctic seas to Central America; and as having probably its counterpart in South America, along the line of the Andes.

Under the Quaternary, the three periods are, as before, the Glacial, Champlain and Recent, and the same grand continental or epeirogenic movements, first appealed to by the author in 1855, are still recognized as distinguishing them. The Glacial period is divided into three epochs (1) The Early Glacial, or that of the Advance of the ice to its maximum extension; (2) the Middle Glacial, or that of the First retreat; and (3) the Later Glacial, or that of the Final retreat.

Evidence is presented connected with the distribution of birds and other species, proving that during the Glacial period the Antarctic lands were emerged, and that the Antarctic continent, so made, spread northward until more or less closely connected with Australia, New Zealand, South America, Madagascar, and Southern Africa, so that it added to the efficiency of high latitude elevation in giving a glacial climate to the period. The work also states evidence for believing that the semiglaciated condition of South Africa, India and perhaps Australia, in the later Permian, was probably due to similar Antarctic conditions.

Through the Historical Geology, the history of an era is followed by a review of the geological and biological progress made during it, thereby illustrating the stages in Continental growth, and briefly the stages in the history of living species. In the closing chapter of the work, making the last of the series on the Progress in the Earth's life, the author sets forth in a more general way his views on evolution. Referring,—under the heading "Augmentation of variations by interbreeding fundamental in evolution"—to the augmentation of variations by selective breeding, and the strange diversity of results thus educed, he says: "it is perceived that the law of nature here exemplified is not like produces like, but like with an increment," and that "consequently the law of nature, as regards the kingdoms of life is not permanence but change, evolution." Two following paragraphs have the headings: "Natural selection not essential to evolution, variation being effectual without it" (that is the variation that goes forward under the slow and sure processes of free nature); "Natural selection a means of determining the successive floras and faunas of the world, a prominent cause of the geographical distribution of species." Moreover, a "tendency upward" in the Animal Kingdom is stated to be a necessary consequence, under favorable conditions, of the existence of a cephalic nervous mass or ganglion. The theory advocated is essentially the Lamarckian, Evolution by variation," not "Evolution by Natural selection."

The illustrations in the work have been increased in number by more than 400, making the total over 1575, and to them is owing in part the increased size of the volume. They include a bathymetric map of the Atlantic and Pacific oceans, another of the Arctic ocean, a temperature oceanic chart, a map of the Great Lakes; seven maps illustrating the supposed geographical condition of the North American Continent at different times in its history from the Archæan to the Quaternary, a map of the

Yellowstone Park, and others, besides very large additions to the figures of fossils.

This edition is issued thirty-two years after the first, twenty-one after the second, and fifteen after the third. In the preparation of the third, the Historical Geology was only partly revised.

4. *Manual of the Geology of India*, chiefly compiled from the observations of the Geological Survey, by H. B. MEDLICOTT and W. T. BLANFORD.—*Stratigraphical and Structural Geology.* Second edition, revised and largely rewritten by R. D. OLDHAM, Superintendent Geological Survey of India. 543 pp. large 8vo. with maps, plates and illustrations in the text, Calcutta, 1893.—This new edition of the Manual of the Geology of India appears in a single volume. While the size of the Manual has been reduced by omission of less important parts and by condensations, the latest results of the survey of India have been incorporated, and a new colored geological map of the country is among its illustrations. The many peculiarities in the geological structure and orographic history of India make the study of the work of great importance to the geologists of other lands and especially to those of America. The addition of 20,000 feet to the height of the Himalayas after the Miocene period was a marvelous event in geological history; and the great fault-plane of a reversed (or up thrust) fault, "along the whole length of the Himalayas," against which the fresh water Siwalik beds of the Pliocene were deposited to a thickness of several thousand feet (now constituting the Subhimalayas) and other related facts, present orographic problems of profound interest. (On the colored map, a narrow yellow band, extending along the north margin of the great alluvial plain of the Ganges and the south margin of the mountains indicates the position of the Siwalik Hills.) It adds to that interest that while these great changes were in progress in the mountain region, Peninsular India, the lower region, from 500 to over 1000 miles in width, lying between the Himalayas and the Indian Ocean, underwent little change. "The only prominent event which can be attributed to this period is the origin of the western Ghâts."

5. *Recurrence of Ice-Ages.*—PROF. T. MCK. HUGHES, of Cambridge, England, in a paper read before the Cambridge Philosophical Society (Proc. Phil. Soc. 1893–94, 72. 98) entitled "Criticism of the Geological evidence for the recurrence of Ice-Ages," makes the following statements in the course of his concluding remarks. "I have criticised the principal cases in which it has been contended that we have evidence of glacial action in ancient bowlder deposits, and have shown, by reference to actual specimens of the rocks in question, that, not only is the evidence of Paleozoic or Mesozoic glaciation in Britain inconclusive, but that the negative can be proved in all cases hitherto adduced.

Being thus warned against taking on trust evidence for glacial action in ancient times founded upon the form or the condition of the surface of the rock, I venture to throw doubts on the infer-

ence that the faceted stones of Copitz near Pirna, are of glacial origin. I give the results of some of my own explorations among the ancient bowlder clays of Wetzikon, and other localities. I point out that the Cambrian-scratched stones of Norway are in regions that are still under the influence of glacial conditions in spite of the mild influences of the gulf stream. I then give a sketch of the distribution of bowlder-bearing beds in India, Australia and Africa, but have no evidence from personal observation to offer respecting them. I admit that the consensus of many competent observers renders it difficult to believe that these beds do not exhibit evidence of glacial origin."

III. Botany.

1. *Mechanism of the movements of the stamens of Berberis.*—Chauveaud (Comptes rendus, July 2), suggests a new explanation of the curvature of the filament of Barberry, in response to touch or other irritation. He first calls attention to the inadequacy of one of the more widely accepted explanations, namely, that the movement is in consequence of the expulsion of water, showing by a simple experiment that water does not escape from a severed filament. He says that if a stamen be cut off at its base, and held in a dry place, it is possible, after it has recovered and straightened itself, to excite a new bending and after a second straightening to cause a second bending, all of which would not be likely to take place if there was at each movement a true expulsion of water.

According to the author, the following is the anatomical structure of the filament of *Berberis aristata.* Besides the fibrovascular bundle there is a special tissue which occupies about two-thirds of the transverse section and about two thirds of the length. This tissue is formed of narrow, elongated cells which are packed closely. This tissue possesses, especially towards the extremities of the cells, minute intercellular spaces. The transverse walls of its cells are thin, but the longitudinal walls, on the contrary, are thick, with thin places arranged longitudinally. This elastic tissue is covered by a layer which is practically continuous with the epidermis on the internal face and the sides of the filament and which may be called the motile tissue. But this motile layer differs from the rest of the epidermis in many ways. Its cells are rounded and thin-walled on their outer aspect, but notably thicker on the inner or deeper aspect. The contents differ widely from those of the other epidermal cells, being much more opaque. At the bottom of each cell of this layer, there is, when the organ is at rest, a peculiar thickening of the protoplasm into a sort of band. Under the influence of irritation, mechanical, physical, or chemical, the protoplasm reacts. This band suddenly stretches, curves into a bow, and while its ends touch and draw on the side walls, its convexity is pressed against the outer wall, resulting in a shortening and thickening of the cell. This causes a slight but

yet sufficient deformation, and produces a curvature of the filament toward the interior of the flower.

The contractile movements of these cells are very rapid. They demand for their manifestation perfect integrity of the tissue. When the tissue is acted on by Osmic acid, for fixation of the contents of the cells, it presents totally different appearances according to the phase of activity immediately preceding the employment of the reagent. In a state of rest, the protoplasm forms a dark band at the bottom of each motile cell. When the filament is cut longitudinally, these bands give the impresssion of a sort of ribbon, as long as the sensitive portion. But if the filament was in a state of tension when it was fixed, these bands are more or less detached and curved, and present an undulating appearance. These colored and fixed segments of protoplasm are very distinct from the rest of the cell contents, and can be readily photographed.

These intracellular changes had been previously noticed, but had been regarded as enlargements and diminutions of an intercellular substance readily susceptible to changes in the amount of water in the cell. G. L. G.

2. *The Harvard Botanical Museum.*—The accuracy of the glass models of plants and the analytical details of their flowers, made by the botanical artists, Messrs. L. and R. Blaschka, has rendered it possible to exhibit all the morphological relations of more than two hundred North American genera. Above four hundred species from North, South, and Central America are now arranged in such order as to display affinities in a manner perfectly intelligible to every observant visitor. The minutest details are given on an enlarged scale, so that the position and character of the embryo in even the smallest seeds are fully and faithfully presented. All peculiarities of the essential organs and floral envelopes are displayed with absolute fidelity.

The success attending this venture has encouraged the installation of other specimens illustrating all the relations of plants to their surroundings, and to animals; in short, a full presentation of the Biological features of vegetation. In this biological section, the department of economic botany has, of course, its proper place and is to claim its proportion of space. The coöperation of the Director of the Museum of Comparative Zoölogy, at Cambridge, of the Director of the new Museums at Philadelphia, and of the Curator of the Peabody Museum, places in hand sufficient material for the realization of this comprehensive scheme, so far as the Phanerogams are concerned. In the installation of the Cryptogamia, Professors Farlow and Thaxter have given indispensable assistance, and some of their specimens are already in the cases.

From present appearances about two years will elapse before all the relations of plants to their environment can be satisfactorily exhibited, but the systematic and economic departments are now open. The phytopalæontological exhibit will be in the same building, but on a lower floor. G. L. G.

3. *On the amount of absorption of water by roots.*—M. LECOMTE (Comptes rendus, July 9), makes the following interesting statement regarding *Musanga Smithii*, an Urticaceous tree, found in French Congo. The tree attains a height of sixty to seventy-five feet, is much branched, and has compound leaves. One of these trees, having a diameter of a foot and a half, was cut down five feet from the ground, and a groove was made to convey the water for collection. The tree was "felled" at five P. M. Jan. 6, 1894, when the atmosphere was saturated with moisture, but when there was no rain falling. At seven in the morning ($9\frac{1}{4}$) nine and one quarter liters of sap had collected, but it is certain that some was lost during the experiment. Subsequent experiments showed that the amount steadily diminished during the day, thus:

1st, from 6 P. M. to 7 A. M. at rate of 0.711, each hour.
2d, from 8 to mid-day, " " 0.587, " "
3d, from noon to 4 P. M " " 0.360, " "

The author says that the gorilla is acquainted with this property of the species in question, since he tears the branches off, and quenches his thirst at the wounds he makes. G. L. G.

IV. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *Science.*—The well-known weekly Journal, SCIENCE, after a brief period of suspension has recommenced as a new series. The first number, issued January 4th, in the interest and variety of its contents speaks well for its future. It is now under the direction of an editorial committee constituted as follows: Mathematics, Prof. S. NEWCOMB; Mechanics, Prof. R. S. WOODWARD; Physics, Prof. T. C. MENDENHALL; Astronomy, Prof. E. C. PICKERING; Chemistry, Prof. IRA REMSEN; Geology, Prof. J. LECONTE; Physiography, Prof. W. M. DAVIS; Paleontology, Prof. O. C. MARSH; Zoölogy, Prof. W. K. BROOKS, Dr. C. HART MERRIAM; Botany, Prof. N. L. BRITTON; Physiology, Prof. H. P. BOWDITCH; Hygiene, Dr. J. S. BILLINGS; Anthropology, Prof. D. G. BRINTON, Major J. W. POWELL; Psychology, Prof. CATTELL.

It is obvious that there is need in the country for a journal in the field which Science occupies and it is to be hoped that it may receive in full the support which it deserves from all interested in the progress of scientific truth. We quote a few sentences from the excellent introductory editorial by Professor Newcomb.

"At the present day one of the aspects of American science which most strikes us is the comparative deficiency of the social element. We have indeed numerous local scientific societies, many of which are meeting with marked success. But these bodies cannot supply the want of national coöperation and communication. The field of each is necessarily limited, and its activities confined to its own neighborhood. We need a broader sympathy and easier communication between widely separated men in every part of the country. Our journal aims to supply the want of such a medium, and asks the aid of all concerned in mak-

ing its efforts successful. . . . . At the same time, it is intended that the journal shall be much more than a medium for the popularization of science. Underlying the process of specialization which is so prominent a feature of all the knowledge of our time there is now to be seen a tendency toward unification, a development of principles which connect a constantly increasing number of special branches. The meeting of all students of nature in a single field thus becomes more and more feasible, and in promoting intercourse among all such students SCIENCE hopes to find a field for its energies, in which it may invite the support of all who sympathize with its aim."

2. *The Astrophysical Journal:* An International Review of Spectroscopy and Astronomical Physics. Volume I, Number 1, 100 pp. January, 1895. Chicago (The University of Chicago Press.) —This Journal, which is essentially a continuation in a new form of *Astronomy and Astro-Physics*, has for its *editors-in chief*, George E. Hale, Director of the Yerkes Observatory and James E. Keeler, of the Allegheny Observatory. The *assistant editors*, are J. S. Ames, Johns Hopkins University, W. W. Campbell, Lick Observatory, Henry Crew, Northwestern University, E. B. Frost, Dartmouth College, F. L. O. Wadsworth, University of Chicago. There are also ten associate editors, leading men in this department of Science, and equally divided between this country and abroad. The first number now issued contains a number of valuable articles by Professors Michelson, Pickering, Rowland and others. The article by Rowland gives a preliminary table of Solar Spectrum wave-lengths from 3722·071 to 3911·444. Minor contributions and notes fill pages 80–87, and reviews with a list of recent publications, pp. 88–99.

That this journal will prove a great aid to scientific research in the department of Radiant Energy to which it is devoted is too obvious to require comment. It should be generously supported. The Astrophysical Journal is to be issued monthly (except in July and September) and the annual subscription is four dollars.

3. *Cloudland: A study on the structure and characters of Clouds;* by REV. W. CLEMENT LEY. 208 pp. 8vo. London, 1894 (Edward Stanford).—This is a popular discussion of the subject of clouds, presented in attractive form and with an abundance of excellent illustrations, including a number of colored plates. It would be difficult to find elsewhere so complete and systematic a description and representation of the different types of clouds and it will doubtless be of material aid to the individual observer. The latter portion of the work discusses the theory of atmospheric currents, prevailing winds, cyclones and anti-cyclones. In the illness of the author, which has prevented the completion of his work, the volume has been edited by Mr. C. H. Ley.

OBITUARY.

FREDERIK JOHNSTRUP, Professor of Mineralogy at Copenhagen, died in December 1894, at the age of seventy.